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FOURTH SERIES.

VOL. XI—[WHOLE NUMBER, CLXI.]

No. 63.—MARCH, 1901.

NEW HAVEN, CONNECTICUT.
1901.

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 125 TEMPLE STREET.

Published monthly. Six dollars per year. $6.40 to countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

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AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XIII.—*Circular Magnetization and Magnetic Permeability;* by JOHN TROWBRIDGE and E. P. ADAMS.

VERY little quantitative work appears to have been done upon the problem of the intensity of magnetization produced by an oscillatory current in an iron wire. Previous work of this kind has been done with oscillatory currents, either of very much higher frequency or of very much lower intensity than those used in the experiments about to be described.

In 1894, I. Klemencic* gave an account of some experiments on this problem. He studied the effects of the oscillatory currents induced in an iron wire by Hertz waves, reflected and received by parabolic mirrors. By comparing the heat produced in a short iron wire through the action of these oscillatory currents, with the heat produced in a similar non-magnetic wire, he was able to arrive at a value for the effective resistance of the iron wire to oscillatory currents. Then by making use of Lord Rayleigh's formula:

$$R' = \sqrt{\tfrac{1}{2}\mu l n R}$$

he calculated the value of the permeability of the iron. The heat produced in each case was compared by the use of a thermal junction held near the wire under investigation. In this way he arrived at the value 118 for the permeability of the iron to oscillatory currents, and estimated the maximum value of the field strength at 290. He reasoned that since this very large maximum field strength produced such feeble magnetization, the permeability of iron to oscillatory

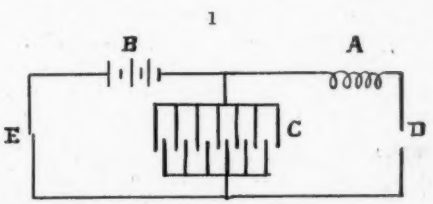
* Wiedemann's Annalen, liii, p. 707.

currents was a constant. The frequency used by Klemencic was about 9×10^7 oscillations per second.

The experiments described below are with oscillatory currents of frequencies ranging from 600 to 3000, with maximum field strengths of higher values than those used by Klemencic. It appears from the results given below that with oscillatory currents of as low frequencies as this, the permeability is not a constant, but depends upon the strength of the magnetic field; that is, the iron behaves toward oscillatory currents in much the same manner as it does toward steady currents.

Similar results were brought out recently in an article by Marchant.* He showed that the same dependence of permeability to field strength holds in the case of oscillatory discharges as in the case of steady currents. No figures are given in his article by means of which a quantitative idea of this relationship may be obtained.

The arrangement of apparatus used in our investigation was as follows: B is a battery of 10,000 storage cells; C a con-



denser consisting of 300 glass plates, coated on both sides with tin-foil, the coated surface being 43×33 centimeters. The battery circuit was controlled by a switch at E. The discharge circuit, CADC, contained a spark-gap at D, of cadmium terminals. The self-induction of this circuit could be changed by placing coils of copper wire of different dimensions at A.

When the switch at E was closed the condenser was charged; it then discharged itself through the circuit CADC. This latter circuit was so proportioned that the discharge was always of an oscillatory character, that is, approximately, by the well-known theory, R^2 was less than $4L/C$, where R is the resistance, L the self-induction, and C the capacity of the circuit. The self-induction of A was large enough so that the self-induction of the rest of the circuit could be neglected; and the electrostatic capacity of the circuit could also be neglected in comparison with the capacity of the condenser.

* Nature, Aug. 30, 1900, p. 413.

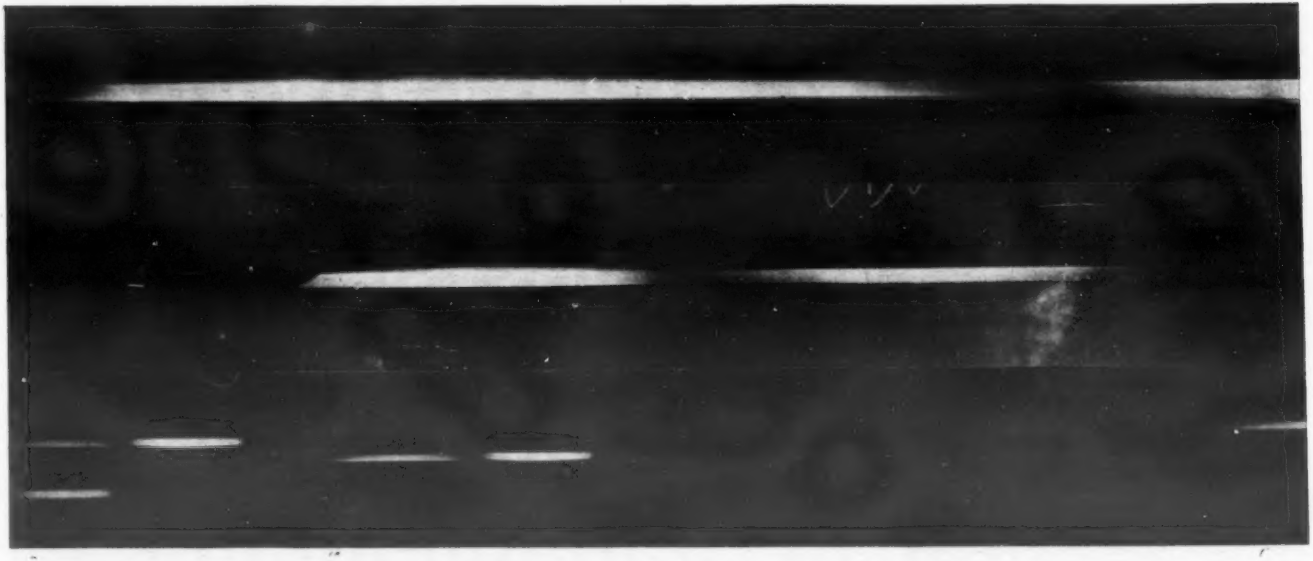


FIGURE 2.—Oscillatory Discharges of a Condenser, With periods 600 to 3,000.

In order to study the frequency of oscillation, the revolving mirror method was used. A concave mirror of about 300 centimeters focal distance was attached to the shaft of an electric motor. The image of the spark was reflected by the revolving mirror upon a photographic plate, and when the plate was developed the length of this image could be measured. Some typical photographs are shown in the accompanying cuts, fig. 2. The speed of the motor was obtained by means of a chronograph, the cylinder of which was directly attached to the shaft of the motor.

The formula connecting the periodic time of an oscillatory discharge, T, with the self-induction, L, and the capacity, C, of a circuit is:

$$T = \frac{2\pi}{\left\{\frac{1}{LC} - \frac{R^2}{4L^2}\right\}^{\frac{1}{2}}}$$

or since $R^2/4L^2$ is very small compared with $1/LC$,

$$T = 2\pi\sqrt{LC}$$

In this formula T is known from the length of the spark on the photographic plate, the distance of the plate from the mirror, and the speed of rotation of the mirror.

C was determined by placing at A a coil of copper wire whose self-induction to steady currents could be accurately calculated. It was then assumed that for the low frequency used, the self-induction to oscillatory currents did not differ appreciably from its calculated value. That this was a legitimate assumption within the limits of experimental error, was shown by the close agreement that existed between this calculated value, and the value obtained by measuring the self-induction by means of Rayleigh's bridge, employing a frequency of about 700. Knowing thus L and T, C could be calculated by the above formula. The value of the capacity obtained for the lowest frequency used. viz: 1·85 micro-farads, agrees very closely with its value measured by comparison with a standard condenser.

Two different coils of copper wire, corresponding to frequencies, when alone in series with the condenser, of 633 and 1423 respectively, were used. For the higher of these two frequencies the capacity was about 5 per cent less than for the lower. Part of this change may have been due to the fact that the change of self-induction of the copper coil was neglected, but this latter was very small.

The iron wire, whose permeability was under investigation, was arranged in the form of a rectangle, around the four sides

of the Jefferson Physical Laboratory—200 feet long and 60 feet wide. The wire was the ordinary soft iron wire, 0·105 inches in diameter. This iron wire was arranged so that it could be put in series with either of the two copper coils, and also so that it could form practically the only self-induction in the discharge circuit.

The general method of procedure was as follows: As stated above, one of the copper coils was placed at A and the capacity of the condenser obtained. Next the iron wire was placed in series with the same copper coil. This of course changed the frequency of the discharge, but since the change was not large, it was assumed that the capacity of the condenser was not sensibly altered. Knowing the periodic time and the capacity, the self-induction of both copper coil and iron wire was given by the formula $T = 2\pi\sqrt{LC}$. Then the self-induction of the iron wire alone was obtained by subtracting from this combined self-induction, the calculated self-induction of the copper coil. Then by means of Lord Rayleigh's formula:

$$L' = l\left(A + \sqrt{\frac{\mu R}{2nl}}\right)$$

the permeability of the iron was obtained.

The same process was repeated using the other copper coil, and the permeability at this different frequency obtained in the same way. Finally the iron was placed alone in the discharge circuit, and the self-induction of this obtained directly from the formula: $T = 2\pi\sqrt{LC}$. In order to get the capacity of the condenser at this highest frequency, it was assumed that it had diminished by 5 per cent. This, of course, can only be regarded as a rough approximation.

The experimental data and calculations follow:

The self-induction of the two coils of copper wire was calculated by means of Maxwell's formula:

$$L = 4\pi n^2 a\left(\log\frac{8a}{R} - 2\right) + 2l\left(\log\frac{D}{d} + 0{\cdot}11835\right)$$

where:

n	number of turns.
a	mean radius of coil.
R	geometric mean distance of cross-section of coil.
l	total length of wire.
D	diameter of insulated wire.
d	diameter of bare wire.

In these coils:

D 0·3969^{cm}
d 0·1241^{cm}

For the larger coil:

a 43·5558
R 2·1292
n 144·
L $3{\cdot}421 \times 10^7$

For the smaller coil:

a 40·2016
R 1·4194
n 64·
L $7{\cdot}125 \times 10^6$

The iron wire was in the form of a rectangle, 200 feet long and 60 feet wide, the diameter of the wire being 0·105 inches. Rayleigh's formula for self-induction with alternating currents is:

$$L' = l\left(A + \sqrt{\frac{\mu R}{4\pi n l}}\right)$$

where:

l length of wire.
R resistance for steady currents.
n number of alternations per second.
μ permeability.

A is a constant, depending upon the geometric form of the circuit, and can be calculated from the self-induction of the circuit with steady currents. For steady currents, Rayleigh's formula becomes:

$$L = l\left(A + \frac{\mu}{2}\right)$$

Using Maxwell's formula for the self-induction of two parallel wires, and applying it to this case, we get for the self-induction of the iron wire to steady currents:

$$L = 4c \log \frac{b}{a} + 4b \log \frac{c}{a} + \mu(b+c)$$

Here

c length of rectangle.
b width "
a radius of wire.
l length of wire.

Hence

$$L = 311200 + 15860\,\mu/2$$

and

$$1A = 311200$$

The resistance of the iron wire to steady currents was measured by means of Wheatstone's Bridge, giving,

$$R = 4{\cdot}3 \times 10^9$$

Thus Rayleigh's formula, for calculating the permeability, when we know the self-induction of the iron wire to alternating currents, becomes:

$$L' = 311200 + \sqrt{\frac{4{\cdot}3 \times 10^9 \times 15860}{4\pi n}}\,\mu$$

Discharging the condenser through the larger coil, we had:

Length of half-oscillation.....	$8{\cdot}98^{cm}$
Speed of mirror.....	3·0
Distance plate from mirror	300·9

From this we find the number of complete oscillations per second to be:

$$n \quad 633$$

Using this value of n, and the calculated value of the self-induction of the coil given above, we find for the capacity of the condenser:

$$C \quad 1{\cdot}848 \text{ micro-farads.}$$

Discharging the condenser through the same coil and the iron wire in series we had:

Length of half-oscillation	$6{\cdot}91^{cm}$
Speed of mirror	2·2
Distance plate from mirror.....	300·9

giving

$$n = 605$$

This gives for the combined self-induction of iron wire and copper coil:

$$L = 3{\cdot}745 \times 10^7$$

Subtracting from this the self-induction of the coil, that of the iron wire becomes:

$$L' = 3{\cdot}24 \times 10^6$$

Substituting this value in Rayleigh's formula we get for the permeability of the iron:

$$\mu = 327$$

Discharging the condenser through the smaller coil alone, we had:

Length of half-oscillation	$7{\cdot}42^{cm}$
Speed of mirror	5·6
Distance plate from mirror	300·9

giving,

$$n = 1423$$

This value of n, with the calculated value of the self-induction of the coil, gives as the capacity of the condenser at this frequency:

$$C = 1{\cdot}756 \text{ micro-farads.}$$

Discharging the condenser through the smaller coil and the iron wire in series, we had:

Length of half-oscillation	$11{\cdot}85^{cm}$
Speed of mirror	8·0
Distance plate from mirror	300·9

giving

$$n = 1280$$

Using 1·756 as the capacity of the condenser, and this value of n, we get for the combined self-induction of coil and iron,

$$L = 8{\cdot}805 \times 10^6$$

Subtracting the self-induction of the coil, that of the iron wire becomes:

$$L' = 1{\cdot}68 \times 10^6$$

And by means of Rayleigh's formula,

$$\mu = 443$$

Discharging the condenser through the iron wire alone, we had:

Length of half-oscillation	$2{\cdot}42^{cm}$
Speed of mirror	4·2
Distance of plate from mirror	300·9

giving

$$n = 3300$$

Assuming the capacity of the condenser to be 1·668 micro-farads, and using this value of the frequency, we get for the self-induction of the iron wire:

$$L' = 1{\cdot}395 \times 10^6$$

By means of Rayleigh's formula,

$$\mu = 711$$

The values of the permeability so calculated are a kind of mean value for a single discharge of the condenser. The magnetic force is that due to the current in the wire, so that the iron becomes circularly magnetized. This magnetic force is 0 at the axis of the wire, and increases to the value $2i/a$ on the circumference, where i is the current and a the radius of the wire. Thus the magnetic force is not a constant over the cross-section of the wire; at any point in the wire its value is $2\pi ir/a^2$, where r is the distance of the point from the axis of

the wire. The mean value, found by integrating this expression over the cross-section of the wire, is:

$$H_{mean} = 4i/3a = 2/3\, H_{max.}$$

The following values were obtained by Klemencic* for the susceptibility of iron wire to a steady circular magnetizing force. The last column gives the permeability as calculated from his results:

i(Amperes)	$H_{max.}$	H_{mean}	k	μ
·12	·23	·15	14·3	180
·23	·43	·29	16·7	210
·46	·87	·58	20·2	255
·85	1·62	1·08	28·7	362
1·26	2·40	1·60	46·8	590
1·45	2·77	1·85	61·2	771
2·39	4·56	3·04	103·5	1304
3·62	6·90	4·60	112·9	1423

These values of the permeability are thus seen not to differ very much from the average values of the permeability with longitudinal magnetization.

From the results of our experiment and the above table, it would seem that the oscillatory currents we employed were equivalent in their magnetizing effects upon the iron wire to steady currents varying in strength from about 0·8 to 1·4 amperes. We can easily get an approximate idea of what the maximum current strength was as follows. The images measured on the photographic plates were in every case the images of the first half-oscillation. Neglecting the damping during this first half-oscillation, which is small, the maximum current is given by the following expression:

$$I_{max.} = \frac{E}{\sqrt{R'^2 + 4\pi^2 n^2 L'^2}}$$

E is the potential to which the condenser was charged. The e.m.f. of each cell was very approximately 2 volts, giving as the total e.m.f.,

$$E = 20{,}000 \times 10^8$$

We can thus form the following table, making use of the maximum current strengths thus obtained, and the maximum magnetic field strengths:

$I_{max.}$ (Amperes)	Frequency.	$H_{max.}$	Permeability.
140	605	53	327
282	1280	106	443
742	3300	278	711

* Wied. Annalen, lvi, p. 585.

It might be supposed that we could have made a known change in the current by employing one-half the battery to charge the condenser. One-half, however, was not sufficient to charge the condenser to such a degree that sufficient light could be obtained in the spark. We believe that the following inference, however, is correct: the permeability is seen to increase with increasing field strength, in spite of the increase of frequency. But the increase of permeability with increase of field strength is seen to be much less rapid than in the case of steady currents. For, from the table of Klemencic, a permeability of 327 corresponds to a maximum current of about 0·8 amperes, while a permeability of 711 corresponds to a current of about 1·4 amperes. But in the case of an oscillatory discharge, these two values of the permeability correspond to maximum currents of 140 and 742 amperes respectively. This clearly shows the effect of period in diminishing the permeability; for the same change of permeability is produced by increasing the currents in the ratio 8 : 14 with steady currents as is produced by increasing the currents in the ratio 1 : 5 in the case of oscillatory currents.

Jefferson Physical Laboratory, Harvard University.

ART. XIV.—*Notes on the Geology of Parts of the Seminole, Creek, Cherokee and Osage Nations;* by CHARLES NEWTON GOULD.

DURING the month of August, 1900, while engaged in the Oklahoma Geological Survey, I was enabled to make a brief reconnaissance of the northwestern part of the Indian Territory and the Osage nation, Oklahoma. The trip was made by wagon and occupied in all about two weeks. I was accompanied by Mr. Paul J. White, botanist to the survey, and Mr. Roy Hadsell, general assistant. The route lay through Cleveland and Pottawotamie counties, Oklahoma, and the Seminole, Creek, Cherokee and Osage nations. The chief towns through which we passed were Shawnee, Keokuk Falls, Okmulgee, Sapulpa, Tulsa and Pawhuska.

The object of the trip was primarily to ascertain the general geological features of the region, and particularly to locate the eastern extremity of the Red-beds. Incidentally it was intended to locate the position of the heavy ledges of limestone which were supposed to extend southward from the Flint hills of southern Kansas into the western part of the Creek nation.

As is well known, the Flint hills or Permian mountains extend north and south across Kansas, reaching their culmination in Cowley, Butler, Chautauqua, Elk and Greenwood counties in the southeastern part of the State. For the most part these hills are composed of massive ledges of limestone containing great quantities of flint in the form of nodular concretions. Besides the limestones there are beds of green, blue and reddish shales of considerable thickness. The entire series is fossiliferous. The fossils of the lower part of the hills indicate that the rocks are of Upper Carboniferous age, while those from the summit are Permian. The Cottonwood Falls limestone, which lies near the point of division of these groups, is located near the top of the Flint hills.

Few ledges of sandstone are found except in the extreme southern part of the State. In the vicinity of Dexter, Cowley County, Kansas, a bed of arenaceous shale immediately beneath the Strong flint (Prosser) changes into a ledge of light brown sandstone. This ledge may be traced south past Maple City to the State line, and thence down Beaver creek to the vicinity of the Kaw agency. By this time, however, several other ledges of sandstone have come in. The section of a hill at the mouth of Beaver reveals the presence of six ledges of sandstone each from five to fifteen feet thick, alternating with limestone and shale.

This is intended to show that while the Flint hills in Kansas consist almost entirely of limestones and shales, still on the

southern line of the State sandstones have already begun to appear. To the south these conditions obtain more and more until the limestone is entirely replaced by sandstone. Even in Kansas the rock east of the Flint hills is sandstone and shale. To the west the limestones gradually thin out and give place to shales (the Marion and Wellington formations) which farther west are succeeded by the Red-beds. South of the State line the sandstones from the east and the Red-beds from the west begin to approach each other, while the limestone ledges become thinner and thinner and the flint less pronounced.

In Pawnee County, Oklahoma, there are still some heavy ledges of limestone, although even here sandstones greatly predominate. In eastern Payne County, fifty miles south of the Kansas line, the conditions have changed still more. The following section taken at Ingalls will illustrate the succession of the various rocks:

Section at Ingalls, Oklahoma.

No.		Feet.
13.	Red clay and sandstone	20
12.	Red sandstone	2
11.	Red clay shale	20
10.	Two ledges of hard, flinty, fossiliferous limestone, 1 to 2 feet thick, separated by 1 foot of greenish clay	5
9.	Red clay shale	50
8.	Sandstone	5
7.	Red and green shale	10
6.	Limestone	1
5.	Shales	10
4.	Limestone	1
3.	Greenish shale	5
2.	Limestone	1
1.	Shales	20
	Total	150

No. 10 forms the cap of the noted Twin Mounds, seven miles east of Ingalls, as well as the tops of numerous bluffs and escarpments in the vicinity. It is the most pronounced ledge in the region and is the one that gives tone to the erosion forms. It will be observed, however, that of the 150 feet of strata represented but eight feet are limestones, the remainder being either sandstone or shale, with the latter predominating. Above the rocks represented in this section only shales and sandstones of the Red-beds are to be found. The gradation from the underlying Permian or Carboniferous to the superjacent Red-beds is so slow that when on the spot it is not easy to tell just where the one leaves off and the other begins. At

Ingalls, as shown above, there is a fifty foot ledge of red clay which may not be distinguished from typical Red-beds clay, below the thickest limestone ledge in the region. On the State line there are several hundred feet of blue and green shales between the upper limestone and the base of the Red-beds.

In general, however, it may be observed that in going eastward from a Red-beds region toward the Carboniferous the sandstones and shales, which have been of a deep brick-red color, become more and more brownish and grayish, and finally lose entirely their characteristic hue and take on that of the older formations. The lithology changes also, but so gradually that it is impracticable if not impossible to fix any but an arbitrary line of separation between the two groups.

With these facts in mind the reconnaissance was undertaken. In the absence of evidence to the contrary it was assumed that the limestones forming the southern extension of the Flint hills extended as far south as the Seminole nation. The plan, then, was to go east from Norman, Oklahoma, until these limestone ledges were encountered and then to follow them northward to the Kansas line. This object was not accomplished for the reason that on the eastern trip no limestones were found. As will be shown later, the only time when the party encountered the Flint hills was in the Osage nation, on the road from Pawhuska to Winfield. While the trip extended much farther east than had been planned, still this fact need not be regarded as an unmixed evil inasmuch as it enabled us to visit a region the geology of which has not been well understood.

From Norman to Shawnee the rock is prevailingly red. About the west line of the Seminole country the sandstones begin to lose their red color and are usually brown or even light gray. These ledges are frequently quite pronounced and in many localities form prominent escarpments or even hills of considerable size. Keokuk Falls of the North Canadian, on the north line of the Seminole reservation, is formed by one of these ledges. From Keokuk Falls to Okmulgee, a distance of fifty miles, only sandstones and shales appear. The sandstone ledges are often many feet thick and dip slightly to the west or southwest. The peculiar "stair-step arrangement" so noticeable in the Carboniferous of Kansas is observed throughout the region. Prominent ledges appear to the east as the escarpment of a bluff or hill. To the west these dip lower and lower and finally disappear beneath the bed of a stream, while they are succeeded above by other ledges.

These sandstones are not barren of fossils; the more common Carboniferous types being abundant in certain localities. Beds of coal are reported from the vicinity of Okmulgee. At Henry-

ville, a few miles south of Okmulgee, extensive beds have been located and are now being worked.

From Okmulgee to Sapulpa, thirty-five miles north, the same geological conditions obtain. Massive ledges of sandstone continue to give tone to the erosion forms. Two isolated buttes a few miles east of the "Frisco" railroad are so prominent as to have received the name of "Twin Hills." In the vicinity of these buttes the only ledge of limestone seen on the trip, except that in the Osage nation, was observed. The ledge is not to exceed two feet thick and is cut in a remarkable manner by joints running nearly at right angles. These joints are from twelve to twenty inches apart and in many cases extend the entire thickness of the ledge. As a result the limestone is cut into regular cubical blocks. In a number of places where the ledge is exposed in the bed of a stream these blocks have been pried out and used for foundations or stone walls. This rock requires very little dressing and will doubtless prove a source of considerable income.

In the region around Sapulpa and between that place and the Arkansas river at Tulsa, the sandstone ledges continue. Buttes and narrow ridges bordered by high and steep bluffs are frequent. Taneha mound, five miles east of Sapulpa, is perhaps the most typical of these. It is situated on the high prairie with its base 100 feet or more above the level of the Arkansas river at Tulsa. The sides of the hill are grass-covered and do not reveal the strata except the more prominent ledges of sandstone. The following section taken along the east slope illustrates the general rock structure of the country:

Taneha Mound Section.

No.		Feet.
10.	Sandstone forming cap of mound	10
9.	Slope	15
8.	Sandstone forming prominent terraces	5
7.	Slope	40
6.	Sandstone forming terraces	10
5.	Slope	30
4.	Sandstone forming a broad terrace	5
3.	Slope	20
2.	Sandstone	10
1.	Slope from level of prairie 100 feet above the level of the Arkansas	50
	Total	195

Of this 195 feet of strata 40 feet consist of sandstone. The remainder, or 155 feet, is chiefly arenaceous shale. From the top of the mound a magnificent view of the surrounding country may be obtained. To the south especially is the scene

of particular geological interest. The dip of the sandstone ledges to the west is distinctly noticeable, and no fewer than five "stair steps" may be noticed from this point. Coal is found in several places in the vicinity. From what I was able to learn it occurs in at least two beds. On Coal creek, five miles east of the mound, a vein three feet thick is reported. Oil is also said to be present, although this can scarcely be authenticated as yet.

The most eastern point reached on the trip, and the lowest geologically, was the Dawson coal field in the west-southwest corner of the Cherokee nation. In the vicinity of Dawson the country is gently rolling. The coal is obtained by stripping. At present it is taken from a depth of from ten to fifteen feet. The rock dips quite strongly to the southwest. The following section shows the location of the vein:

Dawson Coal Field Section.

No.		Feet.
4.	Evenly laminated light brown shales with regular cleavage lines and some concretions	10
3.	Coal	2½
2.	Shales like No. 4, grading upward from No. 1	8
1.	Massive gray or yellowish sandstone, becoming shaly above and grading into No. 2	15
	Total	35½

Other exposures of the same vein are found for several miles both north and south of Dawson. Outcrops are reported from numerous points along Bird creek all the way to Skiatook, a distance of more than twenty miles. This promises to become one of the most productive coal fields in the territory.

From Dawson to Pawhuska, a distance of 45 miles, the road lay up the valley of Bird creek. The hills are often steep and rugged and the bluffs are capped by ledges of massive or cross-bedded sandstone. Although no opportunity afforded to secure complete sections of the rocks of the region, the following (p. 190) is believed to present a fairly accurate provisional section from Skiatook to the top of the hill west of Pawhuska, or, in other words, from the upper coal beds to the base of the Flint hills. The dip of the rock continues to be to the west and southwest.

The three most noticeable features of the section are: 1st. The great predominance of sandstones and sandy shales. Of the entire section less than fifty feet consist of limestone. The three ledges of limestone are located near the center of the section and are well exposed on the bluffs below Lewis

Bird Creek Section.

No.		Feet.
9.	Massive sandstones and arenaceous shales extending from Lewis Rogers' place, thirty miles southwest of Pawhuska, to the top of the hill five miles west of Pawhuska	600
8.	Fossiliferous limestone	10
7.	Fossiliferous sandstone and shale	50
6.	Limestones with fossil shells and crinoids	5
5.	Sandstones and shales	100
4.	Massive fossiliferous limestone	20
3.	Arenaceous shales with ledges of sandstone	200
2.	Two thin ledges of limestone containing great quantities of fossil corals "Camptophyllum torquium" in ledges of sandy shale	25
1.	Sandstones and shales from Skiatook	100
	Total	1110

Rogers'. 2d. The strong and uniform dip of all the rocks to the west. This dip will average perhaps ten to fifteen feet per mile. 3d. The entire series is fossiliferous. This is the best fossil field in the territory that has come to my knowledge, and should be thoroughly studied. The ledges numbered 6, 7 and 8 particularly will reward investigation. All of these ledges are well exposed on the bluff back of Ben. Avant's farm, thirty-five miles southeast of Pawhuska.

From near Pawhuska to Winfield, Kansas, our route lay across the Flint hills. Massive ledges of limestone with flinty concretions, alternating with beds of calcareous shale, composed practically all the rock seen. The only sandstone noticed was on Beaver creek and near Maple City, spoken of above. The Flint hills have been too often described to require more than a passing mention in this place.

The results of this trip may be summarized as follows:

1. The Flint hills do not extend as far south as the Seminole country.

2. The sandstone, which is well developed in the eastern part of Chautauqua County, Kansas, continues uninterruptedly southward east of the Flint hills, beyond the North Canadian river.

3. The eastern limit of the Red-beds in southern Oklahoma is not far from the western part of the Seminole country.

4. A line of coal beds extends north and south near Bartlesville, Skiatook, Dawson, Tulsa, Okmulgee and Henryville. These beds vary much in thickness.

5. There is no reason to doubt that gas and oil will eventually be found near these coal beds.

The University of Oklahoma,
Nov. 26, 1900.

ART. XV.—*Names for the formations of the Ohio Coal-measures;** by CHARLES S. PROSSER.

FIELD work during the past three years has acquainted the writer with the formations composing the Coal-measures of southwestern Pennsylvania, Maryland and northern West Virginia. It was, therefore, quite natural in reviewing the classification of the Ohio formations that those of the Coal-measures should be among the first to be considered.

The Ohio Geological Reports contain a wealth of statements regarding the details of the formations and some that are conflicting. The writer makes no claim to have harmonized these various differences, but he has acquainted himself with the general nature and limits of the formations, so that he is able to compare the Ohio classification with that of the Appalachian.

Without attempting to trace the complete development, the more important features of the classification of the Appalachian Coal-measures may be briefly summarized.

Henry D. Rogers, in the final report of the First Geological Survey of Pennsylvania, proposed and defined the following divisions of the coal strata, or Seral series as he termed them, which are arranged in descending order:

Upper Barren Coal-shales.
Upper Productive Coal-measures.
Lower Barren Coal-shales.
Lower Productive Coal-measures.
Seral conglomerate (or lowest division of the Coal-measures.)†

Under the description of the divisions the names are slightly modified and there is a lack of uniformity in the wording in the several places in which the names occur, but the following, omitting the conglomerate, is an approximation:

Newer Coal-shales or Upper Barren group.
Upper or Newer Coal-measures.
Older Coal-shales or Lower Barren group.
Older or Lower Coal-measures.‡

The Lower Barren group was defined as having "for its inferior limit the top of the Upper Freeport coal, and for its superior boundary the bottom of the great Pittsburg bed."§ This also fixed the top of the Lower Coal-measures, the base

* Presented to the tenth meeting of the Ohio State Academy of Science, Columbus, December 27, 1900.

† Geology Pennsylvania, vol. i, 1858, p. 109.

‡ Ibid., vol. ii, pt. 1, pp. 16–20. § Ibid., p. 19.

of which was not so sharply defined, although it was stated in general that it rested directly on the conglomerate; but in the anthracite region, where the two are closely united, Prof. Rogers reported that "considerations of convenience dictate that we place an arbitrary boundary at the bottom of the first or lowest considerable coal-seam."* The Upper or Newer Coal-measures were defined as extending "from the bottom of the Pittsburg coal to the top of the Waynesburg seam,"† and the Upper Barren group contained the remainder of the coal rocks which were found in the southwestern corner of the state.

From this classification has come the one in general use, which is stated as follows, by Dana, in the last edition of his Manual:

Upper Barren Measures.
Upper Productive Measures.
Lower Barren Measures.
Lower Productive Measures.‡

In 1872 Prof. Stevenson described the Coal-measure formations as shown in Monongalia and Marion counties, West Virginia, stating that he "thought it best to adopt the terms used in the Geology of Pennsylvania and the Virginia Reports, for, though they may not have been based on scientific grounds, they are most convenient for description, as the rocks are here developed."§ Under the descriptions of the formations, or groups as they were termed, names derived from geographical terms were used as synonyms for the Lower and Upper Coal groups, the limits of which differed somewhat from those fixed by Rogers.

The Lower Coal group or Allegheny river series extended from "the Great Conglomerate" to the top of the Mahoning sandstone.‖ The base of the formation was drawn at a lower horizon than has generally been the case in later classifications, for it included the Tionesta sandstone and coal (Coals Nos. 18 and 20 of the section), while the higher coal (No. 14 of the section) was correlated with the Brookville, which later has come to be regarded as very near the base of the Allegheny formation. The upper limit of the formation at the top of the Mahoning sandstone also differed from that of the Lower Coal-measures of Rogers, which was drawn at the top of the Upper Freeport coal at the base of the Mahoning sandstone.

The Upper Coal group or Monongahela river series extended from the base of the fire clay immediately underlying the Pittsburg coal to the top of the Waynesburg sandstone, which was given as from 31 to 55 feet above the top of the Waynesburg coal,¶ while the Upper Coal-measures of Rogers extended

* Geology Pennsylvania, vol. i, 1858, p. 17. † Ibid., p. 19.
‡ Manual of Geology, 4th ed., 1895, p. 648.
§ Trans. Am. Phil. Soc. Philadelphia, 2d Ser., vol. xv, p. 16.
‖ Ibid., pp. 27–30. ¶ Ibid., p. 17.

from the base of the Pittsburg to the top of the Waynesburg coal.

When the Second Geological Survey of Pennsylvania was organized Mr. Franklin Platt was engaged as Assistant Geologist to describe the bituminous coal fields of western Pennsylvania, and, as a result of his field work in 1874, the following year he published a table of Paleozoic formations in which geographical names were used for those of the Coal-measures with the exception of the Upper Barren Measures. The names of the formations under consideration are as follows:

Upper Barren Measures.

Monongahela	M. Brownsville (Washington) coal.
	L. Waynesburg coal.
	K. Sewickley coal.
	J. Redstone coal.
	I. Pittsburg coal.
Conemaugh	Middle Barren Measures.
	Mahoning sandstone.
Allegheny	E. Upper Freeport coal.
	Freeport limestone.
	D. Lower Freeport coal.
	Freeport sandstone.
	C. Kittanning coal.
	B′ Ferriferous coal.
	Ferriferous limestone.
	B. Clarion coal.
	A. Brookville coal.

Conglomerate No. XII, (Seral).*

It will be seen from the above that the Allegheny formation extended from the base of the Brookville coal to the top of the Upper Freeport coal; the Conemaugh formation from the last mentioned horizon to the base of the Pittsburg coal, and the limits of the Monongahela formation differed from those of the Upper Coal-measures of Rogers in that they extended from the base of the Pittsburg coal to the top of the Washington coal, or the one succeeding the Waynesburg coal. The important point in connection with this classification is that geographical names were used for the three formations which compose the Coal-measures proper of Pennsylvania, and the terms based upon the presence or absence of valuable beds of coal abandoned, so that the classification was brought into harmony with the names used for the older Paleozoic formations. Modifications of this classification were published later by Pratt† and in 1877 he used the name Monongahela

* Second Geol. Surv. Penna., H, 1875, p. 8.

† Ibid., L, 1876, pp. 12, 17, 23; and H^3, 1877, pp. xxiii, xxiv.

River system to cover all the rocks from the highest Upper Barren Measures to the base of the Upper Productive Coal Measures, while those included between the horizon last mentioned and the top of the Pottsville conglomerate were called the Allegheny River system.

Lesley also in the same year divided the Carboniferous system into first the *Monongahela River Coal Series*, which included the rocks from the highest of the Upper Barren Measures to the base of the Upper Productive Coal-measures, and second the *Allegheny River Coal Series*, which apparently comprised all the rocks from the top of the Lower Barren Measures to the base of the Pocono sandstone.*

In some respects these modified classifications appear less desirable than the original one and, according to the practice of the U. S. Geological Survey which is now quite generally followed by American geologists, the names Monongahela and Allegheny having already been used for divisions of smaller rank, were not available as names for these two divisions.

In 1876 Prof. Stevenson divided the Upper Barren series into two groups, the upper one termed the Greene County group, which included all the rocks above the Upper Washington limestone; and the lower one, named the Washington County group, which extended from the top of the Washington limestone to the top of the Waynesburg sandstone, an horizon some 80 feet above the Waynesburg main coal.†

Professors Fontaine and I. C. White carefully studied the flora of the Upper Barren Measures and reached the conclusion that the "Upper Barrens of the Appalachian coal field are of Permian age."‡

In 1891 Dr. I. C. White published his excellent work on the "Stratigraphy of the bituminous coal fields of Pennsylvania, Ohio and West Virginia," in which he named the Upper Barren Measures the Dunkard Creek series,§ stating that "the rocks of this series . . . . . begin with the roof shales of the Waynesburg coal and extend upward to the topmost beds of the Appalachian region."‖

In 1896 Messrs. N. H. Darton and Joseph A. Taff published a description of the geological formations of the Piedmont folio, covering the southern part of the extreme western portion of Maryland and a larger area to the south of the North Branch of the Potomac river in the northern part of West Virginia. They gave new names to the Coal-measure formations derived from geographic names occurring in the Piedmont quadrangle, and in general the formations were not separated as they were

* Second Geol. Surv. Penna., H³, 1877, p. xxiii. † Ibid., K, p. 35.
‡ Ibid., Report PP, 1880, p. 119.
§ Bull. U. S. Geol. Surv., No. 65, p. 19. ‖ Ibid., p. 20.

in the earlier classifications. Their list of names, beginning with the Conglomerate, is as follows:

1. The *Blackwater sandstone*, which represented the Pottsville conglomerate.

2. The *Savage formation*, which extended from the top of the Blackwater sandstone or conglomerate to the top of the Davis or Lower Kittanning coal and included nearly the lower half of the Allegheny formation.

3. The *Bayard formation*, which extended from the top of the Davis coal to the top of the sandstone overlying the Fourfoot or Barton coal. This formation contained the upper half of the Allegheny and the lower part of the Conemaugh formation.

4. The *Fairfax formation*, which continued from the top of the Bayard formation to the base of the Elkgarden or Pittsburg coal and contained the remainder of the Conemaugh formation.

5. The *Elkgarden formation*, which contained the rocks above the base of the Pittsburg coal, all of which, with perhaps the exception of the highest, were in the Monongahela formation.*

Upon the organization of the Geological Survey of Ohio by Dr. Newberry a thorough study of the coal deposits of the state was undertaken and to the second report he contributed a "Sketch of the Structure of the Lower Coal Measures in Northeastern Ohio."† Dr. Newberry stated that "North of the National Road we have in Ohio, below the Barren Measures, from six to eight workable seams of coal, forming what is known as the lower coal series."‡ Beginning with the lowest seam, which was called Coal No. 1, they were described and given numbers, the highest one being Coal No. 7,§ which was stated to be "the highest workable seam of coal in Ohio below the Pittsburg bed. . . . . It is overlaid by the great mass of colored shales which form the Barren Coal Measures."‖

At a later date all the names proposed by Prof. Rogers for the Coal-measure formations of Pennsylvania were adopted for those of Ohio, as shown by a "Vertical section of the rocks of Ohio" published in 1873, on which the Coal-measures are composed of the following formations:

"Upper Coal Measures
Barren Measures } 1200 ft."¶
Lower Coal Measures

*Geologic Atlas of the United States; Folio 28, pp. 3, 4, 6 and "Columnar Section."

†Geol. Surv. Ohio. Report Progress in 1870, 1871, p. 14.

‡Ibid., p. 26. §Ibid., pp. 26–44. ‖Ibid., p. 43.

¶Rept. Geol. Surv. Ohio, vol. i, pt. i, facing p. 89.

In the report which followed, Dr. Newberry gave a detailed account of the Carboniferous system of Ohio as then known, and to the list of formations of the former section he added the Upper Barren Measures with a thickness of 300 feet (?) and continued the numbering of the principal coal seams as far as 13 inclusive, of which No. 1 indicated the lowest coal.* In this classification, however, the base of the Lower Coal-measures was carried considerably lower than in Pennsylvania, so that the division contained a considerable part of Rogers' Seral Conglomerate, Coals Nos. 1, 2 and 3 belonging in the Conglomerate.

In 1884 the volume on Economic Geology appeared, containing Dr. Orton's exhaustive account of the Lower Coal-measures of Ohio. The classification of Rogers is quoted and explained,† but the greater part of the Conglomerate was included in the Lower Coal-measures, since this formation began with the lowest coal seam, as was the case in the earlier classification of Newberry. Dr. Orton stated that "In point of fact, there is no more marked separation between the highest coal seam of the Conglomerate series and the lowest of the Productive Measures than can be found between two coals of the latter subdivision."‡ It was shown, however, that Coal No. 4 of Newberry, occurring just below the Putnam Hill limestone, was probably equivalent to the Brookville Coal of Pennsylvania, which in that state occurs at about the base of the Lower Productive Measures or Allegheny formation.§

In 1888 the complete Rogers' classification of Pennsylvania, however, was adopted, as is shown in the following table:

"Upper Barren Coal Measures	500 feet
Upper Productive Coal Measures	200 feet
Lower Barren Coal Measures	500 feet
Lower Productive Coal Measures	250 feet
Conglomerate Group	250 feet"‖

Regarding the change in the classification for the two lower divisions from that of the preceding report, is the following explanation: "In the review in Vol. V, the Conglomerate series of Pennsylvania was included with the Lower Coal Measures, though the boundaries of each were shown to be clearly recognizable here. There are, however, less imperative grounds for the separation in Ohio than in Pennsylvania and

* Rept. Geol. Surv. Ohio, vol. ii, pt. i, 1874, "Section of the Carboniferous rocks of Ohio," facing p. 81.

† Rept. Geol. Surv., vol. v, pp. 1, 2.

‡ Ibid., p. 10. §Ibid., pp. 160, 230.

‖ Ibid., vol. vi, p. 3; see also "Vertical section of the rocks of Ohio," facing p. 4.

the Virginias, and if only the Ohio series were to be classified, it is not probable that the divisions would have been made. But they stand for great and conspicuous facts elsewhere, and it probably would have been better to have maintained them in our territory also. The separation will be recognized in this review."*

The same classification was used by Dr. Orton in his last report of the Ohio Survey,† which also contained a chapter on "The Coal Fields of Ohio" in which he described the coal seams of the Conglomerate Coal-measures, the Lower Coal-measures and the Upper Productive Measures.‡

The Maryland Geological Survey has carefully considered the Carboniferous formations and adopted the classification shown in the following table, which gives the approximate thickness and composition of the formations as exposed in Georges Creek valley in the western part of Allegany county:

Georges Creek, Md., Section of the Coal-measures and Permian.

Dunkard 400′.	400′	Mainly argillaceous shales, some thin limestones and sandstones and an occasional thin layer of coal.
Monongahela 250′.	2′—	Waynesburg (Koontz) coal.
	116′±	Shales and limestones.
	6′	Sewickley (Tyson) coal and shale.
	100′— 115′	Mainly argillaceous shales.
	14′±	Pittsburg (Elkgarden) or "Fourteen-foot" coal.
Conemaugh About 650′.	144′	Black and gray shales and thin sandstones.
	9′	Franklin (Dirty nine-foot) coal, partly shale.
	72′	Shales and sandstones.
	1′	About one foot of coal.

* Ibid., p. 43.
† Ibid., vol. vii, 1893, pp. 4, 36, 37 and "Geological Scale of Ohio" facing p. 4.
‡ Ibid., pp. 255–291.

Conemaugh About 650′.	187′	Sandy and bituminous shales and sandstones.
	4′	Barton (Four-foot) coal.
	112′	Shales, fire-clay and thin bedded sandstone.
	32′	Partly sandstone, (Upper Mahoning sandstone.)
	2′—	Mahoning coal.
	85′	Massive sandstone alternating with shales. Mahoning sandstone.
Allegheny 300′.	2′—3′	Upper Freeport (Thomas) coal.
	11′	Fire clay and shales.
	1′	Coal
	99′	Shales and sandstones.
	1¼′	Upper Kittanning (?) coal.
	55′	Shales and sandstones.
	6′	Lower Kittanning or Davis (Six-foot) coal.
	30′	Shales and sandstones.
	4′	Split Six-foot coal.
	96′	Fire clay, shales and thin bedded sandstones. In part of the field there is the massive Homewood or Piedmont sandstone at top of the Pottsville conglomerate.*

In Jennings and Braddock runs and on Dans Mountain there are two beds of coal near the base of the Allegheny formation which apparently do not occur in the lower part of Georges Creek valley in the vicinity of Westernport and Piedmont.

The section of the lower part of the Allegheny for this part of the field is approximately as follows:

* A more detailed account of these formations may be found in the report by the Maryland Geological Survey on Allegany County, 1900, pp. 115–130, 166–180.

2′—2½′	Clarion (Parker) coal.
36′	Thin sandstones at top with drab argillaceous shales below. In some localities there is a coal seam 18′ above the Bluebaugh coal.
2½′—7′	Brookville (Bluebaugh) coal. In the thickest deposit 16″ of shale occurs, 1′ below the top of the coal.
10′±	Homewood sandstone.*

The Maryland Geological Survey fully accepted the modern ruling that the name of a formation should refer to some locality at which the rocks are well exposed. For this reason the time-honored names of Rogers as Lower Productive Measures, etc., which referred to the presence or absence of workable seams of coal, were abandoned, and the names Allegheny, Conemaugh, Monongahela and Dunkard were adopted. With the exception of Dunkard these are the oldest names, derived from geographical terms, proposed for the formations. In regard to the Upper Barren Measures it was thought better to consider them as one formation, hence the name Dunkard of Dr. White, dropping the words "Creek series" as he originally published it, was used instead of the two earlier terms of Prof. Stevenson.

The names proposed by Messrs Darton and Taff were not used because it was considered that the Rogers-Platt classification, which also had priority, was a more satisfactory one.

In our review of the Coal-measure formations of Ohio we have shown that in the final classification their limits correspond to those of Pennsylvania, and, therefore, it is proposed that the names recently adopted for them by the Maryland Geological Survey be used for the same formations in Ohio. This will involve the following changes in the nomenclature of the Ohio formations:

Present names.		*Proposed names.*
Upper Barren Coal Measures	=	Dunkard formation.
Upper Productive Coal Measures	=	Monongahela formation.
Lower Barren Coal Measures	=	Conemaugh formation.
Lower Productive Coal Measures	=	Allegheny formation.

Columbus, O., December, 1900.

*This section of the Georges Creek valley is published with the permission of Dr. Wm. Bullock Clark, State Geologist of Maryland.

Some information concerning the lower part of the formation was obtained from Prof. James Hall's report regarding the north fork of Jenning's run as abstracted in Macfarlane's Coal-regions of America, 3d ed., 1877, p. 256.

Art. XVI.—*A New American Species of Amphicyon;* by J. L. Wortman.

The true genus *Amphicyon* has not hitherto been found in this country, notwithstanding the fact that Leidy, Cope, and Marsh have, at various times, referred certain specimens of extinct dogs, having three true molars in the upper jaw, to this group. Scott has satisfactorily shown that all the Amphicyons of the American Tertiary heretofore described, belong to genera quite different and distinct from the typical genus *Amphicyon* of Europe.

While recently engaged in the examination of some remains of extinct Canidæ in the Marsh Collection at the Peabody Museum, I came across a beautifully preserved palatal portion of a skull, from the Loup Fork Miocene deposits of Nebraska, which I do not hesitate to refer to this European genus. The specimen in question includes all the superior series of teeth with the exception of the incisors, a few premolars of the right side, and the last upper molar of the left side.

As compared with the best known European species, *Amphicyon giganteus* Laurill., from the Middle Miocene of France, great similarity of structure is at once apparent. Like all the Amphicyons the canines are unusually large and robust and are provided with prominent cutting edges, both anteriorly and posteriorly. The three anterior premolars are strikingly reduced in size, the two anterior being separated from each other and from the succeeding teeth by short diastemata. The first premolar is implanted by a single fang, the second and third by two. In comparison with the other teeth, the fourth premolar, or superior sectorial, displays about the same proportions as that of *A. giganteus*, but the internal cusp is less distinct; it appears as a low rounded swelling at the base of the crown, supported by an independent root, and is not so distinct as is usual in the Canidæ. The molars differ considerably from those of *A. giganteus* in that the external portion of the crown is less rounded, has a greater fore and aft extent and the internal less, giving to it a more distinctly triangular appearance, as in the true dogs. Another important difference is seen in the prominence and external position of the basal cusp at the antero-external angle of the first molar in the American species, in marked contrast with the internal position and more reduced character of this element in the European species. It may be remarked that in their general appearance the molars of the American form are decidedly more dog-like, while those of the European species more closely approach the structure displayed by the primitive bears.

After careful examination of the material at hand, I fail to find any characters which would warrant me in placing the present specimen in a genus distinct from *Amphicyon*, although the specific characters seem to be somewhat unusually accentuated. I propose, therefore, to refer to it under the name of *Amphicyon americanus*.

The chief interest in the Amphicyon group lies in the fact that it is through them that the ancestry of the modern bears has been traced directly to a canine origin, apparently by the most exact and satisfactory evidence. This evolution is supposed to have taken place in Europe, and the conclusion has been reached that from this exclusive area of origin they have gradually spread to nearly all parts of the world. However this may be, it is a matter of considerable interest to find one of the ancestral links of the phylum in this country, and one, moreover, which, so far as the superior molars are concerned, is the most primitive yet known.

It is desirable, therefore, to inquire further into the relationship between this Amphicyon and certain other extinct types of the Canidæ found in deposits of preceding age in this country. I am led to undertake this now for the sake of clearness, however brief and imperfect the results may be, pending a more complete study of the Eocene Carnivora which I hope soon to publish.

One of the prime essentials in the way of relationship which these earlier extinct Canidæ must exhibit, is the possession of three true molars in the upper jaw, as the disappearance of the last molar in any of them would certainly mean a two-molared successor. The possession of three superior molars is undoubtedly an archaic feature among the Canidæ, and this condition was retained by some of the phyla until comparatively late in their developmental history. Others again suffered an early reduction in the number of molars, particularly in the superior series, but in the great majority of instances this reduction has consisted in the disappearance of the last molar only. It is somewhat remarkable to find that the molar formula which characterizes the great bulk of the species of the Canidæ to-day was fixed at least as early as the Upper Eocene; and not only has the number, but the general form and proportions, of these teeth remained, up to the present time, unusually constant in that phylum from which the modern genus *Canis* was derived.

Of those types possessing three true molars in the superior series, *Paradaphænus*, a genus established by Matthew and myself,* is the only one which has thus far been found in the

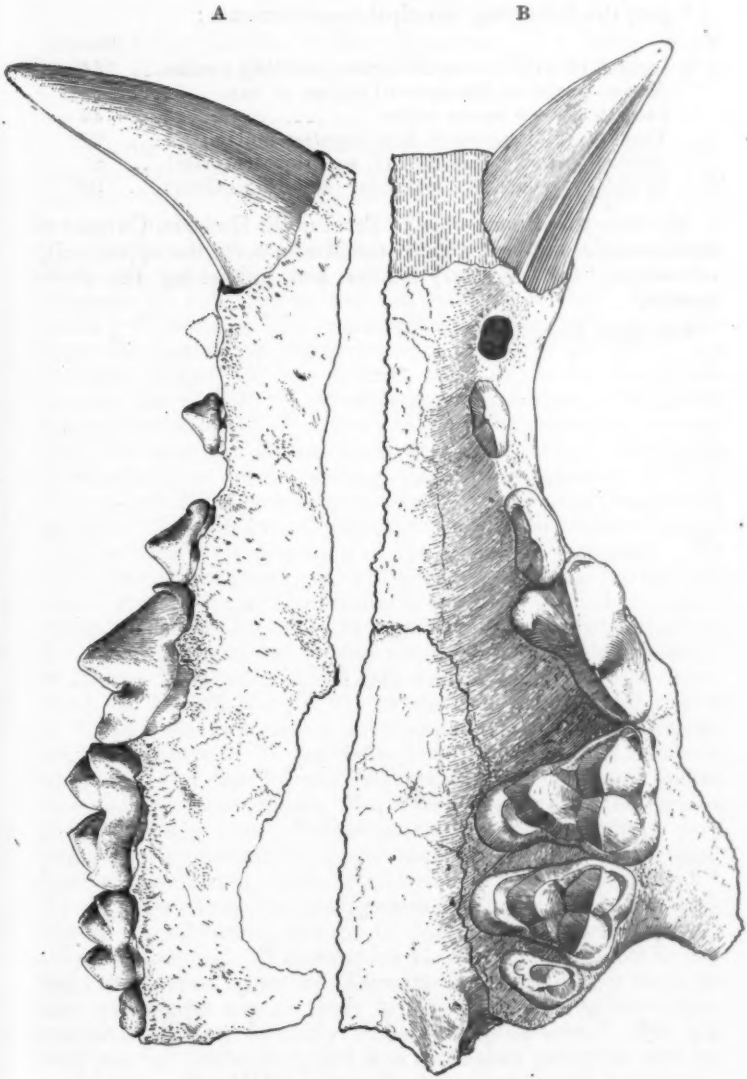
* Bull. Amer. Mus. Nat. Hist., New York, June, 1899, p. 129.

Middle Miocene deposits of this country. It is represented by at least two species from the John Day beds of Oregon and is not uncommon. In the structure of the superior molars this genus agrees closely with *Amphicyon*, in that the crowns are symmetrical and much extended transversely; the last molar, moreover, is but little pushed inwards and the cusps and ridges are relatively high and prominent. There is no apparent reduction in the size of any of the premolars, a fact which would indicate that any species of *Paradaphœnus* thus far known cannot be regarded as directly ancestral to *Amphicyon*.

In the underlying White River beds comes the genus *Daphœnus* Leidy, represented by at least four well-marked species of rather common occurrence. In this group the ridges and cusps of the molars are characteristically low and blunt, the crowns of the upper molars are less symmetrical transversely, and the third molar is pushed inward on a line with the internal cusps. In any of the known species the premolars are not reduced in size to any very noticeable extent. It will be seen, therefore, that the genus is still further removed from *Amphicyon* in its dental anatomy, and on this account must be regarded as off the direct line of ancestry of *Amphicyon*. Next below the White River species is found the genus *Prodaphœnus* W. and M.* from the Uinta or uppermost Eocene, and although but a single specimen consisting of a portion of a superior maxillary is known, yet it serves to indicate with certainty the existence of a three-molared type of the Canidæ in this horizon. This genus is again preceded in the Bridger beds by *Uintacyon* Leidy, which has numerous species reaching as far back as the Wasatch or Lower Eocene.

That which is of especial interest to us in this connection is the fact that certain species of *Uintacyon* and the only known species of *Prodaphœnus* show a marked reduction in the size of the premolars, possessing at the same time a type of molar pattern which could have easily passed into that of *Amphicyon* and thence into the bears. The likeness is not confined to the upper molars, but extends to the lower molars and canines as well. While the materials now known are perhaps too fragmentary and scattering to hazard a definite opinion, yet the resemblances between *Amphicyon* and these Eocene forms are so striking that I cannot believe them altogether due to accident. If this surmise of genetic affinity is correct it will go far towards clearing up the origin of this peculiar and important group of the Canidæ.

* Bull. Amer. Mus. Nat. Hist., June, 1899, p. 115.



AMPHICYON AMERICANUS, Wortman.

Fig. A.—Left upper jaw, palatal view, natural size.

Fig. B.—Left upper jaw, side view, natural size.

Loup Fork beds, Niobrara River, Nebraska.

Type in Yale University Museum.

I give the following principal measurements:

	mm.
Length of superior tooth series including canine...	134
Antero-posterior diameter of canine at base	24
Length of true molar series	46
Transverse diameter of first superior molar	27
Antero-posterior diameter of superior sectorial....	27
Width of palate at first molar including crowns...	98

My best thanks are due to Prof. C. E. Beecher, Curator of the Geological Department of the Museum, for the opportunity of making the necessary studies and publishing the above results.

New Haven, Conn., Jan. 25.

ART. XVII.—*Studies in the Cyperaceæ;* by THEO. HOLM. XV. *Carices* (*Vigneæ*) *astrostachyæ.* (With five figures in the text.)

IN some previously published papers we have directed attention to the classification of the *Carices* in "*Vigneæ*," "*Vigneastra*" and "*Carices genuinæ*" as the most natural method under which the species may be arranged in sections or "greges," as suggested by Drejer in his Symbolæ Caricologicæ. However, this author only treated some of "*Carices genuinæ*," although he fully recognized the stability of the "*Vigneæ*," while "*Vigneastra*" did not appear to him as being separable from the paniculate *distigmaticæ*. While maintaining the *Vigneæ*, Drejer did not restrict this section to distigmatic species alone, but he considered, also, certain tristigmatic species, for instance *C. macrocephala*, as belonging to this section; he admitted at the same time a number of distigmatic heterostachyous species among the *Carices genuinæ*, even if he considered this section as consisting of typically tristigmatic species. The number of stigmata was, thus, of minor importance to Drejer in disposing of the species in "greges." We have already touched upon his views concerning the old section "*Psyllophoræ*," but hitherto we have not had an opportunity to discuss his ideas in regard to the arrangement of all the *Psyllophoræ* under *Carices genuinæ*, as "*formæ hebetatæ*" of these. It is, at least, the only way in which we can understand his remark (l. c., p. 8), "Constituunt ergo Psyllophoræ et Carices genuinæ unam maximeque naturalem sectionem, etc.," inasmuch as Drejer defined the *Psyllophoræ* as monostachyous, and the *Vigneæ* as possessing decompound spikes (spica composita præditas). Moreover, in describing the various forms of perigynium, Drejer points out that, "omnes fere formæ perigyniorum, exceptis maxime evolutis, quæ apud Carices inveniuntur, inter *Psyllophoras* quoque occurrunt." He compares thus the perigynium of *C. polytrichoides* with that of *C. pallescens*, and of *C. Davalliana* with that of *C. sempervirens*, etc. Whatever his views were in respect to the lesser developed types of *Vigneæ*, Drejer does not seem to have considered any of these to be sought among the monostachyous species, formerly called "*Psyllophoræ*." But his work was left unfinished, and it is more than probable that he would have altered his views, had he prosecuted his studies further.

Tuckermann, whose system of *Carex* was published just one year earlier than Drejer's, adopted *Psyllophoræ* and *Vigneæ*

with the same distinction "spica unica" and "spiculæ plures"; further, he proposed "*Vigneastra*," "*Leptantheræ*" and "*Legitimæ*," the last mentioned being identical with *Carices genuinæ*. This author, however, seems to have detected some affinity to exist between certain *Psyllophoræ* (*Dioicæ*) and *Vigneæ* (*Stellulatæ*), since he makes the following statement about the former (*Dioicæ*), "Stellulatas referentes." In a lately published paper upon South American *Carices* Rev. G. Kükenthal accepts *Vignea*, *Vigneastra* and *Eucarex* (*Carices genuinæ*), and he recognizes five sections among the *Vigneæ: Muricatæ* Fr., *Remotæ* Aschers, *Canescentes* Fr., *Alatæ* Kükenth. and *Capituligeræ* Kükenth. While this author refers certain *Psyllophoræ* (*Nardinæ* Fr.) to *Vignea*, he does not suggest these to represent lesser developed types of any of the other sections, and the reason may be, that the South American *Capituligeræ: C. trichodes* Steud., *C. capitata* L. and *C. caduca* Boott, constitute a small and isolated group of species with no immediate relatives among the higher developed *Vigneæ* of that region, the extratropical South America.

The systematic position of a number of monostachyous species of *Carex* thus remains to be decided upon, and it seems as if Tuckermann were the first author who felt warranted in referring some of these to *Vigneæ*, the *Dioicæ* to the *Stellulatæ*, while both Drejer and Kükenthal considered several of these as "formæ *hebetatæ* of *Carices genuinæ*." It may be that the original type of *Carex* was dicœcious and that it resembled our monostachyous species, and that both *Vigneæ* and *Carices genuinæ* developed from such monostachyous forms as two parallel branches, a theory that has been discussed so excellently by a German author, August Schulz, in a paper upon the morphology of *Carices*. There would in this way hardly be any reason to object to the disposition of some of the monostachyous species among *Vigneæ* as "formæ hebetatæ:" lesser developed types of which habit and structure might point towards the earliest fundamental forms of the genus.

In looking over the *Psyllophoræ* as this section is understood by Tuckermann, it is evident that several of these species have no other character in common than that taken from the structure of the inflorescence, being an almost simple spike, androgynous or sometimes dicœcious. The purely staminate inflorescence and the staminate portion of the androgynous invariably represent true spikes, while the pistillate, as we have described in previously published papers, are always decompound, though less so in these species than in others, where several pistillate spikelets may be united so as to form spicate, more or less ramified inflorescences. In the *Psyllo-*

phoræ the sectional character is thus: "spica unica simplicissima androgyna sive dioica," and Tuckermann divided these in nine subsections: *Dioicæ*, *Nardinæ*, *Pulicares*, *Paucifloræ*, *Filifoliæ*, *Scirpinæ*, *Obtusatæ*, *Polytrichoideæ* and *Rupestres*, of which the names readily indicate what species are comprised under these subsections. But on the other hand the characterization of these minor sections is in several cases well comparable with that of several of the *Vigneæ* and *Carices genuinæ*, as defined by Tuckermann, with the only exception of the lesser decompound inflorescence. We find among the *Dioicæ* such species enumerated as *C. dioeca*, etc., *C. exilis* and even *C. capitata* L., the last mentioned being followed by *C. nardina* Fr. (*Nardinæ*), and it seems strange that Tuckermann considered *C. capitata* as being such a close relative of *C. dioeca*, rather than placing it under *Nardinæ*. Elias Fries in enumerating the Scandinavian *Carices** has, also, the *Psyllophoræ* classified as his *Monostachyæ* distinct from his "*Homostachyæ*:" *Hyparrhenæ* and *Acroarrhenæ*, while Kunth only recognized *Vignea* and *Carex*, the former containing all the species with bifid, the latter those with trifid style, thus each of these sections is represented by both mono-, homo- and hetero-stachyous species. The number of stigmata, however, is of little importance in classifying *Carices*, inasmuch as we have already pointed out, the number of stigmata being by no means a constant character in several species of *Vigneæ* and *Carices genuinæ*.

In regard to the distribution of the sexes, diœcious forms are not restricted to the *Psyllophoræ* either, but occur among the *Vigneæ*, e. g., *C. sterilis* Willd., *C. Douglasii* Boott, and occasionally among the *Carices genuinæ: C. Parryana* Dew., besides that *C. acuta* L. sometimes occurs with purely staminate spikes, the so-called variety *anomala* Lge., which has been found in Denmark. The very interesting *C. Boottiana* Benth. is only known as diœcious, but Boott† referred it nevertheless to *Carices genuinæ* on account of its close affinity to *C. Baltzelli* Chapm. However these cases of diœcism may well be considered as exceptional among *Vigneæ* and *Carices genuinæ*, while there are typically diœcious species among the *Psyllophoræ: C. dioeca*, *C. parallela*, etc. The character "spica unica" as applied to all the *Psyllophoræ* is, on the other hand, not constant, and we remember for instance that in both *C. scirpoidea* and *C. exilis* additional, lateral spikes may be developed, consisting of several pistillate flowers. Drejer referred *C. scirpoidea* to his *Sphæridiophoræ*, and

* Fries Elias: Summa vegetabilium Scandinaviæ. Sectio prior. Upsala, 1846, p. 73.

† Boott, Francis: Illustrations of the genus Carex, vol. i, London, 1858, p. 16.

Boott* says of *C. exilis*: "The existence of these distinct spiculæ necessarily separate the species from the *Psyllophoræ*. It proves the correctness of the remark of Drejer, that that artificial group is to be considered as "formæ hebetatæ Caricum; monostachyæ incipiunt, evaduntque pliostachyæ. The evident affinity of *C. exilis* is with the *Stellulatæ* . . . .;" a similar suggestion was also made by Tuckermann, as mentioned above.

In looking over the *Vigneæ* and *Carices genuinæ* monostachyous specimens are sometimes met with, especially among the latter, but such forms are hardly to be considered as typical, even if they may be quite common, for instance *C. typhina* and *C. squarrosa*, both of which abound in the vicinity of Washington, D. C., with a single gynæcandrous spike, subtended by several leaf-like bracts, indicating the suppression of the lateral spikes; these forms have, also, been found in many other places in the eastern United States, and seem to predominate, the typical pliostachyous forms being much less common in certain regions. It thus appears as if the *Psyllophoræ* in general exhibit some characters by which they may be distinguished from the other *Carices:* "spica unica simplicissima androgyna sive dioica," as indicated by Tuckermann, but beyond this distinction most of the species are readily noticed to be inseparable from *Vigneæ* or *Carices genuinæ*. This becomes the more evident when we consider the structure of utriculus, which furnishes such excellent characters for distinguishing the species and even the "greges," and is of much greater importance than those characters, which are derived from the less decompound inflorescence, the number of stigmata and the separation of the sexes in some of the species. When speaking of utriculus, we must admit, however, that this exhibits a peculiarity which seems characteristic of a number of *Psyllophoræ* in contrast to the *Vigneæ* and *Carices genuinæ* in general; and is evidently a sign of lesser development. This is to be noticed in the orifice of utriculus, which is unequally slit in the *Dioicæ;* thus the upper margin is almost entire on the ventral face, but cut down more or less deeply on the dorsal, the convex face. In the higher developed forms, *Vigneæ* and *Carices genuinæ*, the beak is mostly bidentate or cut down equally on both faces, especially so in the latter. But this character, the unequally slit orifice of utriculus, is not peculiar to all the *Psyllophoræ* and is, moreover, to be observed in some of the *Carices genuinæ*, as pointed out by Drejer. But otherwise the utricle does not show any difference of importance, by which the *Psyllophoræ* may be distinguished from the other *Carices*,

*Ibidem, p. 17.

neither in regard to the mere outline, when considered in transverse section, or as to the minor details of the anatomical structure. The presence of a seta, which, as we have described in previously published papers, depends only upon the prolongation of rhacheola, has by some authors been considered as characteristic of *Psyllophoræ*, being especially well developed in *C. microglochin*, *C. Fraseri* and several others, but is, also, common to many species of *Carices genuinæ*. If we finally compare the position or rather the direction of utriculus in immature and mature specimens of the *Dioicæ*, we notice certain accordances with some of the other *Carices*. In *C. dioeca*, for instance, the utricles are erect during anthesis, but spreading, when the fruit is mature. This change of direction is, also, noticeable in the other species of *Dioicæ* (excluding *C. capitata*), but is, moreover, characteristic of a number of other *Carices* with the spikes squarrose at maturity (*C. echinata*, *C. flava*, *C. Pseudocyperus*, etc.), while in others the utricles maintain their original erect position, being more or less appressed to the rhachis as in *C. vulgaris*, *C. misandra*, *C. pratensis*, etc.

In summarizing these general characters, those that were formerly looked upon as being peculiar to the *Psyllophoræ*, and those which they have in common with the other *Carices*, we cannot consider these monostachyous species as constituting a section or grex distinct from the others, but we feel more inclined to accept them as lesser developed types and referable to the greges of *Vigneæ* and *Carices genuinæ*, in the same way as we already outlined the *Stenocarpæ*, including *C. lejocarpa* and *C. circinata* as formæ hebetatæ of these. In the present paper, it is our intention to demonstrate the affinities of the *Dioicæ*, as understood by Tuckermann, although we have felt obliged to exclude *C. capitata* L., which, according to our opinion, is better placed among the *Nardinæ* Fr., as already suggested by Rev. G. Kükenthal. These dicœcious species are as follows: *Carex dioeca* L., *C. gynocrates* Wormskj., *C. parallela* Læst., *C. Davalliana* Sm. and *C. exilis* Dew. However, moncœcious forms are known of all these species and are so common in *C. gynocrates* and *C. exilis*, that it is difficult to say whether these two are typically dicœcious or moncœcious, and in regard to the former this was originally described as a moncœcious species with androgynous spike, being the most prevalent form in Greenland. Since then the species has, also, been collected on the North American continent and in Kamtschatka as moncœcious and dicœcious, the latter being undoubtedly the most frequent form in this country. If Meyer's *C. Redowskyana* be identical with *C. gynocrates*, the plant from Kamtschatka is truly dicœcious. To separate

these two forms, the monœcious from the diœcious, as distinct species would not be advisable, inasmuch as we have found no other distinction between these, neither morphological or anatomical, than the varied distribution of the sexes, a character that seems of little import, scarcely even of varietal value. *C. gynocrates* may be considered as being most frequently diœcious, and among the large number of specimens which we have examined from various parts of this country and from Greenland, there were c. 400 diœcious individuals against 76 with androgynous spike. *C. monosperma* Macoun is among these specimens, and we have failed to find any other distinction between this and *C. gynocrates* than the smaller number of pistillate flowers, often only one, at the base of the staminate spike. If we consider the geographical distribution of *C. gynocrates*, it seems as if the monœcious form is the most prevalent in the north, judging from the specimens we have examined, which were collected in Northern Labrador, Alaska and Greenland, where we found this species probably at its most northern limit, "Skarvefjæld," on the island Disco, above 69° N. lat., where it occurred only as monœcious.

In regard to *C. exilis*, this species represents a still more evolute stage, and occurs as diœcious or monœcious, mono- or plio-stachyous. A gynæcandrous spike is frequently met with in this species, besides that the female plant may possess several lateral spikes, from one to six, at the base of the terminal. *Carex Davalliana* exhibits a similar variation, possessing androgynous or gynæcandrous spikes besides purely staminate or pistillate, and, moreover, a few pistillate flowers may be found interspersed with staminate in the middle portion of the spike. Although the male plant is very abundant in Switzerland, Gaudin* states that the female is exceedingly rare. If we now examine the monœcious forms of *C. dioeca* and *C. parallela*, we find these as being much rarer than in the species mentioned above. *Carex dioeca* L. var. *isogyna* and *C. parallela* var. *androgyna* possess only from one to three pistillate flowers at the base of the otherwise staminate spike, but these forms are only known from a very few localities in Northern Europe. We have, thus, in the *Dioicæ* an analogous variation represented by all the species, but merely depending upon distribution of sexes, while in *C. exilis* the variation extends still further, the monostachyous inflorescence passing over into a pliostachyous. The characterization formerly applied to these species "spica simplicissima androgyna sive dioica" is actually applicable to each of these, besides that one possesses occasionally a "spica composita" (*C. exilis*).

* Gaudin, I., Flora Helvetica, vol. vi, 1830. p. 27.

In regard to the general habit of these species, *C. Davalliana* and *C. exilis* possess a cespitose rhizome, while in the others the rhizome is stoloniferous; in *C. Davalliana* var. *Sieberiana* Opiz, by Fiegert considered as a hybrid between *C. dioeca* and *C. Davalliana*, the so-called *C. Fiegertii* Vollm.,† the rhizome is not so densely cespitose and often bears short stolons. A very slender and stoloniferous rhizome is observable in both the diœcious and monœcious forms of *C. gynocrates*. The leaves are very narrow in all the species, and the culm is terete and hollow in *C. dioeca*, *C. gynocrates*, *C. Davalliana*, pentagonal in *C. parallela* and obtusely triangular in *C. exilis*. The utricle is usually thickest at the base and tapers gradually into a beak, the orifice of which is cut down on the dorsal face so as to form a slit, but on the ventral side the upper margin is almost entire or slightly emarginate. In *C. exilis*, however, the beak is bidentate with erect teeth. In the last mentioned species, the utricle is, furthermore, a little winged and the margins are very scabrous, especially above, in which character it differs from the other species of the *Dioicæ*. In *C. dioeca* and *C. exilis* the ventral face of utriculus is flat in contrast to the dorsal, which is distinctly convex; in the other species both faces are convex, and the ventral often prominently so in *C. gynocrates*. Nerves are quite distinct on the dorsal face of all the species, less so on the ventral, and are very faint in *C. dioeca* and *C. parallela*. The base of utriculus is thick and spongy, especially after fecundation has taken place.

Another peculiarity common to the *Dioicæ* is the change of direction of the utricle when the achenia are mature. While thus utriculus is erect in these species during anthesis, it gradually bends down later on and occupies a horizontal position in *C. gynocrates*, *C. Davalliana* and *C. exilis*, or it becomes merely spreading (suberect) as in *C. dioeca* and *C. parallela*.

The scale-like bracts (squamæ) which subtend the pistillate spikelets are persistent in these species, while they are deciduous in some of the other *Monostachyæ*, e. g., *C. pulicaris*, *C. nigricans* and *C. pyrenaica*, in which the utricles show a similar change of direction after fecundation has taken place.

By possessing several morphological peculiarities in common, the *Dioicæ* may, thus, be considered as naturally allied species. However, we do not feel satisfied with the arrangement of these species as simply representing a section of their own and separated from *Vignea* and *Carices genuinæ* only on account of their lesser decompound inflorescence and their frequent diœcism. It would seem more natural if these *Dioicæ* could

* Vollmann, Fr., Ein Beitrag zur Carex-Flora der Umgebung von Regensburg. (Denkschr. d. k. bot. Gesellsch. Regensburg, vol. vii; new series, vol. i, 1898.)

be arranged with some of the higher developed "greges," and the extreme forms of *C. exilis*, those which possess several lateral spikes at the base of the terminal, suggest some affinity with *C. echinata* Murr., as already observed by Tuckermann and Boott. In *C. echinata* and its allies the direction of utriculus undergoes the same change as we have described as characteristic of the *Dioicæ*, and, moreover, the structure itself of this little organ (utriculus) shows several analogies, which seem to indicate some affinity to exist between these species. We are, thus, more inclined to arrange the *Dioicæ* of Tuckermann (excluding *C. capitata*) under *Vignea* rather than under *Carices genuinæ*, and the reason is not so much because they are distigmatic, but on account of the structure of utriculus, which suggests affinities with *Vignea*, but not with the other *Carices*.

In regard to *C. echinata* Murr. a number of very diverse species (*C. loliacea*, *C. canescens*, etc.) have been considered as its nearest allies by writers of different periods, who have treated the genus. Nevertheless *C. sterilis* Willd.* is, beyond

* Having studied what Professor L. H. Bailey supposes to be "types" of various species of *Carex*, this author arrived at the conclusion that *C. echinata* Murr. from the Pacific slope appears to be the same as the European plant, but that the type does not occur in the Eastern United States. At that time (1889) Professor Bailey accepted *C. echinata* as an American species with some varieties, among which the var. *microstachys* Bœckl was considered identical with *C. sterilis* Willd and *C. scirpoides* Schk. on the strength of some specimens preserved in the herbaria of Willdenow and Schkuhr. A few years later (1893) Prof. Bailey made still another disposition of the same species by eliminating *C. echinata* altogether from the North American flora, stating that Francis Boott many years ago "questioned if the American plant is the same as the European *C. echinata*." We are not aware that Boott made this statement in regard to this species in North America, but only so far as concerns specimens from "South of the British provinces" (Ill. genus Carex, vol. i, 56, 1858) which he could not satisfactorily refer to the European plant. While thus excluding *C. echinata* from this continent, Prof. Bailey adopts *C. sterilis* Willd. as a species and identical with *C. scirpoides* Schk, of which he claims to have seen the originals. Whether these specimens were the "original" or not, it must be borne in mind that the old botanists did not work with types, and in most cases, it is nothing but a mere guess whether this or that herbarium-sheet contains the specimen, or part of it, from which the original diagnosis was drawn. And it appears to us that this modern investigation of old specimens supposed to be types, arises from inability to faithfully comprehend the descriptions. If, for instance, the old specimens preserved of *C. sterilis* and *C. scirpoides* were "the types," and moreover, identically the same species," one would necessarily expect to find the diagnoses equally uniform; but this is not the case, at least not as these species were understood by Willdenow. Let us, therefore, compare the most salient points in the diagnoses of these three species, *C sterilis*, *C. scirpoides* and *C. echinata* as described by Willdenow with the one by Prof. Bailey, who has adopted *C. sterilis* as identical with *C. scirpoides*, and formerly even with *C. echinata*.

Willdenow.	Inflorescence.	Utriculus.	Squamæ.
C. sterilis.	Spicis dioicis subsenis alternis oblongis contiguis.	fruct. ovatis compresso-triquetris acuminatis, apice recurvis bicuspidatis.	ovatæ acutæ capsulas subæquantes.

doubt, a close ally, and *C. elongata* L. and *C. læviculmis* Meinshaus. show so many points in common with *C. echinata*, that they may well be arranged in the same section; to these, we think, may be added *C. remota* L., but only as a "forma desciscens." The central type of the section seems best illustrated by *C. echinata* Murr., the *C. stellulata* Good., from which we have derived the name "*astrostachyæ*" as being the most appropriate for this new section, while the other species may be classified as follows:

Carices (*Vigneæ*) *astrostachyæ.*

hebetatæ	*C. dioeca* L. *C. parallela* Læst. *C. gynocrates* Wormskj. *C. Davalliana* Sm. *C. exilis* Dew.
centrales	*C. echinata* Murr. *C. sterilis* Willd. *C. elongata* L. *C. læviculmis* Meinshaus.
desciscens.	*C. remota* L.

Further research will evidently prove that several other species may be referable to this section, but we have not at present been able to find any others in the very considerable material of the genus which we have studied. It is readily noticed from the above, that we have restricted the number of

Willdenow.	Inflorescence.	Utriculus.	Squamæ.
C. echinata.	Spica androgyna composita, spiculis subquaternis remotiusculis inferne masculis.	ovato-acuminatis bidentatis horizontalibus.	ovatis acutis
C. scirpoides.	Spica andr. comp, spiculis subquat. inferne masculis subapproximatis, ellipticis.	ovatis bidentatis compressis.	ellipticis obtusis.
Prof. Bailey:			
C. sterilis Willd. incl. *C. scirpoides* Schk.	3 to 5 contiguous spikes of which the uppermost is usually conspicuously attenuated at base by the presence of staminate flowers.	thin and flat, conspicuously contracted into a slender beak which is nearly or quite as long as the body.	.....

It is readily seen from the above, that Willdenow had some reason for distinguishing these plants from each other, and that the collective diagnosis, as presented by Prof. Bailey, is too vague to be considered.

allied species in a very considerable degree by omitting *C. canescens*, *C. loliacea*, *C. tenella*, *C. leporina* and several others, which, according to our opinion, do not seem to belong to this section, at least not when we consider the characters, drawn from inflorescence and utriculus. We have enumerated *Carex gynocrates* as a species distinct from *C. dioeca* L., and we have done so after a careful study of a large number of specimens from various regions, besides comparing these with the excellent diagnosis presented by Drejer in his "Revisio critica Caricum borealium." The habit of these two species is the same, but it appears as if the spikes, "squamæ and utriculi," of *C. gynocrates* are generally paler and of a more dull brown color than those of *C. dioeca*. Furthermore the utricles are merely spreading (subarrecti) in *C. dioeca*, but horizontal or sometimes almost reflexed in the other. Utriculus is plano-convex and drawn out into a long, flat and scabrous beak in *C. dioeca*, while in *C. gynocrates* this organ is nearly gibbous (biconvex) and the beak is shorter in proportion to the body, terete and a little curved. The scales (squamæ) are obtuse in *C. dioeca*, but more or less acute in the latter species. These morphological characters we consider much more important than those taken from the distribution of the sexes, inasmuch as androgynous spikes are, also, known in *C. dioeca*, as mentioned in the preceding pages. It might seem, however, as if these characters, possessed by *C. gynocrates*, are not sufficient for distinguishing it as a species, and that it simply represents a geographical variety of *C. dioeca*, a suggestion that has been made by both Mr. C. B. Clarke and by Rev. G. Kükenthal "in litteris."

If we examine the central forms, *C. echinata* and *C. sterilis* show a structure of utriculus which reminds us very much of that of *C. exilis*, with the only difference that the base is much broader in the former two species; otherwise the margins are distinctly winged, the beak scabrous and bidentate. In *C. elongata* and *C. læviculmis* the body of utriculus is narrower and tapers more gradually into the beak, which is also bidentate in these species, but less rough or nearly glabrous, besides that the margins are not winged. When the achenes are mature we notice in these species (*formæ centrales*) the same change of direction in the utricle as described as characteristic of the *Dioicæ* (formæ hebetatæ), and especially so in *C. echinata*. In regard to *C. remota* this species possesses a utricle of somewhat different structure, since the beak is not pronounced, but bidentate and scabrous; the margins are narrowly but plainly winged, and the base is somewhat thick and spongy as in all the others; at maturity the utricles are spreading, and the species *C. remota* appears to us as inseparable

from the section, even if the structure of utriculus leads us to consider it as a "forma desciscens."

In respect to the general habit the central forms and *C. remota* are all cespitose with long, narrow leaves and rather weak culms; the spikes are small and, the uppermost at least, gynæcandrous or purely pistillate; they are mostly contiguous but in *C. læviculmis* they are distant, and especially so in *C. remota*, in which, furthermore, the lower bracts, subtending the spikes, are developed into long leaves, more or less overtopping the inflorescence. The peculiar stellate appearance of the mature spikes is common to all and suggests the affinity with *C. exilis* and its allies among the formerly so-called *Dioicæ*. There are, however, among the other species of *Vigneæ* several which possess similarly spreading or even horizontally directed utricles, but the shape of this organ, besides its internal structure, seems very distinct from what we have observed in the *Astrostachyæ*. The diagnosis of the section, derived from the central forms, is as follows:

Carices (Vigneæ) astrostachyæ.

Spikes gynæcandrous or the lower ones purely pistillate, sessile. Bracts not sheathing, short and filiform. Utricles horizontally spreading at maturity, broad and spongy at the base, glabrous, nervose, tapering into a distinct beak with scabrous, winged margins and bidentate apex, the teeth erect; stigmas two. Mostly northern species with light-brown or greenish spikes. The lesser developed forms to be sought among the *Dioicæ*, of which *C. exilis*, especially, shows transition to *C. echinata*. *C. remota* may be considered as representing the limit of the section.

When considering the geographical distribution of these species, it appears as if only two are confined to this continent, *C. exilis* and *C. sterilis*, of which the first is a very local plant, only known from some localities in the northeastern section of this country, New Jersey, New Foundland and Eastern Canada; *C. læviculmis* is, also, quite rare, having been recorded from a few places in Kamtschatka, Alaska and Oregon, also from Idaho and Washington Territory, from where Mr. Kükenthal states (in litteris) that he has received some specimens; *C. gynocrates* is known from the west coast of Greenland and from a number of places on this continent especially in the northern and western sections, and also from the Rocky Mountains; it occurs, furthermore, in Alaska and extends from there to Kamtschatka and the Bajkal Mountains; *C. dioeca* and *C. parallela* are inhabitants of the northern countries of Europe and Asia, and the latter species is not infre-

quent in the Arctic region and the higher mountains of Norway; *C. Davalliana* is a more southern type distributed over Middle Europe and some parts of Asia, Altai for instance; *C. elongata* shows a corresponding distribution, but extends a little farther north, at least in Europe; *C. remota* accompanies *C. elongata*, but seems to be more frequent and is, moreover, known from Sikkim Himalaya, where it reaches an elevation of 12,000 feet;* it is, also, known from Japan. The widest geographical range is, however, exhibited by *C. echinata*, which is very abundant in Europe and Asia; besides it is, also, known from North America and New Zealand; *C. sterilis* has been reported only from this continent, from Canada to Carolina (fide Boott). While thus the dicœcious *C. parallela* and *C. dioeca* appear to have their center of distribution farther north than any of the others, the monœcious *C. gynocrates*, although being much less frequent, exhibits a similar range in contrast to its dicœcious form, which is more southern. *C. exilis* represents the most evolute stage of the "*hebetatæ*" and may be considered as a good illustration of the development of the section in this country with its herd of *C. echinata* and *C. sterilis* in a number of varieties, of which only the typical *C. echinata* is distributed in the old world. The nearest allies of *C. echinata* are, thus, to be sought in this country, where, moreover, *C. gynocrates* and *C. læviculmis* have their geographical center. *C. dioeca* and *C. parallela* are, no doubt, the oldest remnants of the section as this is preserved in recent time, and actually demonstrate a closer affinity to *C. exilis* than to *C. gynocrates* and *C. Davalliana*, even if *C. exilis* may be considered as younger than any of these. *C. elongata* and *C. remota* possess certain points in common with the others, and may represent the farthest developed types in the section. While thus, considered from a geographical viewpoint, the earlier types belong to the northern parts of the old world, the more modern forms are represented farther south, not only in Europe and Asia, but also in New Zealand and in this country. It might seem strange that the "formæ hebetatæ" of the section are so remote from each other as they really are: *C. dioeca* and *C. parallela* in Europe and Asia, *C. gynocrates* in this country, without being connected with each other by some circumpolar type; yet we must bear in mind that the development of the section and the migration of the species is not by any means to be fully explained by the present geographical range of a few old types, that are still in existence.

We have in the preceding pages given a brief account of the morphological characters of the *Astrostachyæ*, and we

* Clarke, C. B., *Cyperaceæ* in Hooker's Flora of British India, vol. vi, London, 1894, p. 699.

might append to these some observations upon the internal structure of the species in order to illustrate the section as completely as possible.

The root.

Having examined roots of a number of specimens from widely separated localities and of different age and development, we have, nevertheless, failed to detect any anatomical character of importance by which the "*formæ hebetatæ*" might be distinguished from each other or from their allies among the "*centrales*" and "*desciscentes.*" Like most of the other *Carices* examined, the root possesses a hypoderm of a single layer inside the epidermis, and this tissue is thinwalled in all the species of *Astrostachyæ.* The cortex is differentiated into two zones, an outer and an inner, of which the former is distinctly thickwalled in contrast to the inner, which shows the usual tangential collapsing. The endodermis is more or less thickened, but as it seems constantly as an U-endodermis; it is very heavily thickened in *C. echinata*, less so in the other species. In *C. gynocrates* the endodermis showed only a very slight thickening of the inner cell-wall in specimens from arctic Greenland, while others from Canada, Alaska and Wyoming showed a very pronounced thickening of both the inner and radial cell walls. The pericambium is usually thinwalled or moderately thickened as in *C. exilis*, *C. echinata*, *C. sterilis* and *C. læviculmis;* it was found to be interrupted by all the proto-hadrome vessels, without exception, in all the species of the *Astrostachyæ* The leptome and hadrome is well developed, and the central portion of the root is occupied by conjunctive tissue, which is quite thickwalled in all the species, especially in *C. exilis*, *C. echinata* and *C. sterilis.*

In considering the development of the outer cortex, the endodermis and the conjunctive tissue, the roots of these species seem well supported in mechanical respect, and equally well in species from bogs or woodlands.

The rhizome.

The rhizome of the "formæ hebetatæ" is stoloniferous in *C. dioeca*, *C. gynocrates* and *C. parallela*, but cespitose in the other species. Epidermis is mostly thickwalled, and a hypoderm of a single stratum is noticeable inside the epidermis. The cortical parenchyma is, also here, differentiated into two zones, of which the outer is quite thickwalled. The endodermis shows the same manner of thickening as observed in the roots, and is especially thickwalled in *C. parallela* and *C. Davalliana.* The stereome occurs in *C. parallela* as a peripheral band of small isolated groups near epidermis, but is in the

other species only observable inside endodermis, where it forms a few strata around the mestome-bundles. The arrangement of the mestome-bundles is somewhat variable in these species; in *C. dioeca* and *C. gynocrates*, for instance, they form one very regular band, while two in *C. exilis*, three in *C. Davalliana*, and in *C. parallela* they seem scattered without order inside the endodermis; they occur mostly as collateral and bicollateral, perihadromatic, together, but in *C. gynocrates* we noticed only the collateral type in specimens from Greenland, Alaska and Canada, while in some rhizomes from Wyoming the mestome-bundles showed a tendency to become perihadromatic. Most of the mestome-bundles in *C. Davalliana* were observed to be bicollateral, while only a very few showed this structure in *C. exilis*. The pith occupies a very small portion of the central-cylinder in *C. parallela* and *C. Davalliana* and is solid in these species; in the others, on the contrary, the pith is larger and broken in the middle so as to form a wide central cavity.

The stem.

A triangular and solid stem is generally attributed to the *Cyperaceæ* in contrast to a cylindric and hollow culm in the *Gramineæ*. There are, however, many exceptions to this rule, and in both orders; we have, already, called attention to the outline of this organ in the "formæ hebetatæ" of *Astrostachyæ* being mostly cylindric and hollow inside. *Carex exilis* is the only species of these in which the stem is triangular, though merely obtusely; but if we examine the higher developed types we find the stem to be triangular in all the species with the exception of *C. echinata*, in which it is almost regularly hexagonal; the pith seems invariably broken down in these species, as we, also, observed in the lesser developed types. The epidermis is quite thickwalled in all the species and nearly glabrous, the development of prickle-like projections being very scant except in *C. elongata*. The cortical parenchyma consists of short palisades radiating towards the center of the stem in the "hebetatæ," also in *C. echinata*, *C. sterilis* and *C. elongata*, while in *C. læviculmis* and *C. remota* the bark is composed of polyedric cells and no distinct palisades; intercellular spaces are very distinct in all the species, and lacunes are present, one between each two mestome-bundles; thus the cortical parenchyma does not represent any very firm or solid tissue in these species, and is especially open in *C. elongata*. Stereome occurs as hypodermal on the leptome-side of the larger mestome-bundles, besides that it is, also, developed on the hadrome-side of these, where it borders on the pith; at the smaller mestome-bundles there is less stere-

ome, and, with the exception of *C. læviculmis* (fig. 1), this is here separated from the epidermis by strata of cortical parenchyma on the leptome side. It may be said about the stereome in these species, that it is generally well developed and seems to be especially thickwalled in *C. læviculmis* and *C. remota*. In regard to the mestome-bundles, these are arranged in one peripheral band and represent larger, in transverse section oval, and smaller, which are nearly orbicular in outline; the parenchyma-sheath is thinwalled and the mestome-

1

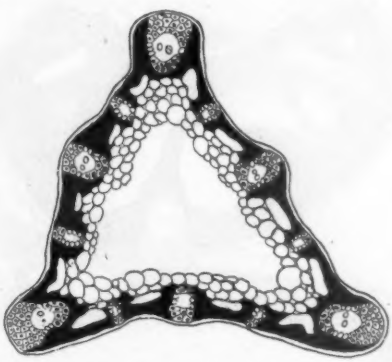


FIG. 1. Transverse section of the stem of *Carex læviculmis* Meinshaus. The cortex is painted black in the figure, lacunes are to be seen between the mestome-bundles, and the central portion of the pith is broken down into a wide cavity. ×75.

sheath shows a distinct thickening of the inner cell-wall in all the species, and to the same extent. The mestome-bundles are thus of the same development as is usually observed in the genus, and we might state besides, that we found no trace of the inner chlorophyll-bearing sheath, which Haberlandt and Rikli detected in some of the other genera of the order.

The leaf.

This organ exhibits a much greater variation in these species than observed in the root, the rhizome and the stem. It is mostly hemicylindric in the "hebetatæ," at least in *C. dioeca*, *C. gynocrates* (fig. 2) and *C. exilis*, where this leaf-shape is characteristic of both the male and female plant, besides in monœcious specimens of *C. gynocrates;* in *C. parallela*, on the other hand, we noticed the leaf to be broader in the male than in the female plant, and in *C. Davalliana* the leaf is still broader and almost carinate. In the central forms as well as

in *C. remota* we find the leaves to be almost flat with a distinct keel as is characteristic of the majority of the higher developed *Vigneæ* and *Carices genuinæ*. In the "hebetatæ" the leaves are smooth and mostly glabrous, with the exception of *C. Davalliana;* in the others, "centrales and desciscentes," we find prickle-like projections to be quite abundant along the margins and the midrib, rendering the leaves more or less scabrous. Very characteristic in this respect is the leaf of

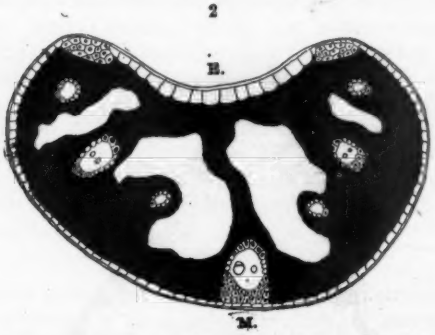


FIG. 2. *Carex gynocrates* Wormskj.; monœcious specimen from Wyoming; transverse section of leaf; mesophyll painted black; M.=midrib; E.=epidermis of upper face. ×120.

C. læviculmis (fig. 4), of which both surfaces show the development of a number of obtuse papillæ. The cuticle is very distinct and smooth in all the species, and the epidermis shows relatively the same modifications as seen in most of the other *Carices:* the cells being generally larger on the upper face outside the mesophyll than on the lower. Bulliform cells are well developed as a single group above the midrib in all the central forms and in *C. remota*, besides that an additional group of these may be seen in *C. remota* (fig. 3) above one of the lateral mestome-bundles. The "hebetatæ" are mostly destitute of these bulliform cells, and it is only in the broader leaves of *C. parallela* (male specimens) and of *C. Davalliana* that some of the epidermal cells have attained such development, although in a much smaller degree than in the "formæ centrales." If we consider epidermis of the lower surface and outside the stereome, we notice the cells to be of a somewhat different size and shape than in the surrounding stomatiferous strata; the radial walls are less undulate and the cells often shorter and narrower than those adjoining. In *C. parallela* and in *C. exilis*, for instance, these epidermal cells outside the stereome are shorter than the others; in *C. Davalliana*, *C. sterilis*, *C. remota* and *C. læviculmis* they are much narrower.

but not shorter, while in *C. echinata* and *C. elongata* the same cells are not only much narrower, but also shorter than the others. The stomata are restricted to the lower surface of the leaf-blade outside the mesophyll; they are free in all species, even in *C. læviculmis* with its numerous papillæ, and the guard-cells are level epidermis in most of the species, with the exception of *C. parallela*, *C. sterilis*, *C. elongata* and *C. læviculmis*, in which they are slightly projecting.

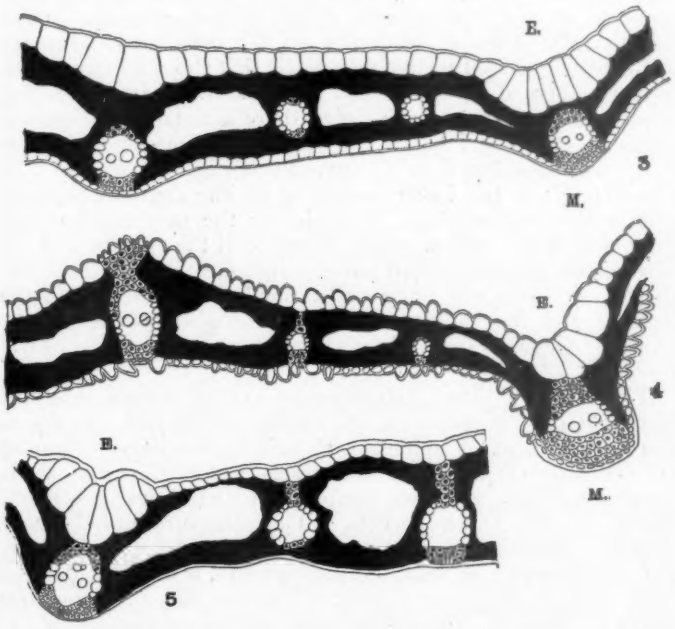


FIG. 3. *Carex remota* L.; fig. 4, *C. læviculmis* Meinshaus.; fig. 5, *C. echinata* Murr. Transverse sections of leaves; M.= midrib; E.= epidermis of upper face, developed in bulliform cells above the midrib; mesophyll painted black. ×120.

The mesophyll consists mostly of a homogeneous tissue of short palisades vertical on the leaf-blade or radiating towards the center of the mestome-bundles as we observed in *C. Davalliana;* in *C. echinata*, *C. sterilis* and *C. læviculmis* the palisades are very short and often too irregular in shape to be called "palisades." In *C. remota* the mesophyll is differentiated into a ventral palisade- and dorsal pneumatic-tissue, this species being, thus, the only one of the section that possesses a typical bifacial leaf-blade. The cells of the mesophyll are

only occasionally closely packed in these species, and intercellular spaces are often not only numerous, but also quite wide; moreover, lacunes are observable in this tissue and are very broad in all the species, in the "hebetatæ," the "centrales" and in *C. remota* (fig. 3).

The stereome is thickwalled and occurs as hypodermal groups accompanying the mestome-bundles, or separated from the epidermis by the mesophyll, or as isolated groups in the leaf-margins. In the "*hebetatæ*" there is only hypodermal stereome on the leptome-side of the midrib, and also in the margins of the blade, while the smaller mestome-bundles are so deeply imbedded in the mesophyll that the stereome which supports these does not extend to epidermis. In the higher developed types ("centrales," etc.) there is usually hypodermal stereome above and below the larger mestome-bundles, especially well developed in *C. læviculmis* (fig. 4), where it is hypodermal on the lower surface at all the mestome-bundles, even at the smallest ones. Considering the mestome-bundles, these constitute only a single band in all the species, and are surrounded by a thinwalled parenchyma-sheath and a mestome-sheath, of which the inner wall is moderately thickened; the leptome and the hadrome exhibit the usual structure, and the bundles occur as oval (in transverse section) or as nearly orbicular.

The leaves of the *Astrostachyæ* exhibit certain modifications not only in respect to the outline of the leaf, but also in the development of epidermis as bulliform cells or as papillæ (*C. læviculmis*); moreover, the bifacial leaf of *C. remota* seems very exceptional, when we compare it with the nearly isolateral leaves of the other species. The structure of *C. exilis*, although this seems to represent the highest developed type of the "hebetatæ," at least morphologically, is actually identical with that of the lower forms: *C. dioeca* and *C. gynocrates*, while in both *C. Davalliana* and certain specimens of *C. parallela* the leaf shows some resemblance to that of the "centrales." A small leaf-surface is characteristic of the "*hebetatæ*" in contrast to the other types, in spite of the fact that several of these occupy the same kind of soil and live under the same climatological conditions; even in *C. gynocrates* and *C. parallela* from high northern latitudes the structure of such specimens agree very well with that of others from more southern latitudes or from subalpine regions.

When we finally compare the "hebetatæ" of *Astrostachyæ* with those of some other sections, we do not observe the leaf-blade uniformly narrow in all of these. We have described the relatively broad leaf of *C. lejocarpa* C. A. Mey. in contrast to that of *C. circinata*, both of the *Stenocarpæ;* further-

more in *C. pulicaris* the leaf is very narrow as in *C. pyrenaica*, but broad in *C. nigricans*, their nearest ally; a relatively broad blade is noticeable in the "hebetatæ" of *Sphæridiophoræ*, e. g., *C. scirpoidea* and *C. oreocharis*, and in *Lamprochlænæ: C. rupestris* and *C. obtusata.*

Utriculus.

If it were not that this organ possesses such excellent morphological characters, by which our species of *Astrostachyæ* may be readily distinguished from each other, one would naturally suppose that the number of species were much smaller by examining the anatomical structure. The fact is, that when we examine the structure of utriculus, we do not find any points of importance by which these species may be distinguished anatomically. The differences are so slight and seem merely to depend upon a relative broader or narrower mesophyll and a larger or smaller number of isolated stereome-bundles, that none of these may be considered as being neither constant or of sufficient importance to be used as anatomical characters. Common to all is the broad mesophyll at the base of utriculus, and the presence of only two mestome-bundles; furthermore, the stereome is equally well developed in these species, not only as accompanying the mestome-bundles, but also by occurring as isolated, hypodermal groups between these. The number of these isolated stereome-bundles varies from 15 to 36, the strongest mechanical structure being possessed by *C. elongata*, *C. dioeca* and *C. gynocrates.* The outer epidermis is thickwalled in most of the species excepting *C. remota* and *C. læviculmis.*

When we finally compare the morphological and anatomical characters with each other, it seems as if our species may be naturally classified as representing a section of *Vigneæ.* The transition from the "hebetatæ" to the "centrales" seems very gradual and as we have shown in the preceding, none of these species possess characters that stand as isolated among the others, neither in morphological or anatomical respects. If our disposition of these species, classified as "*Astrostachyæ*," may prove to be correct or at least quite natural, our observations have simply confirmed a suggestion, already proposed by both Tuckermann and Boott, whose remarks upon the affinities have been presented in the introduction to this paper.

Brookland, D. C., July, 1900.

ART. XVIII.—*A Just Intonation Piano;* by S. A. HAGEMAN.

THE problem of tuning and transposition and just intonation, the practical solution of which is the subject of this paper, is one which does not need to be restated for the readers to whom it will chiefly come. But for their convenience, and for the sake of logical completeness, the intervals of the two scales true and tempered are here given.

Taking, as is usual, the C scale for illustration, the letters designating the tones of a complete octave are given with the intervals between, and the fractions proportioned to the vibration numbers immediately below each letter.

$$\begin{array}{ccccccccccccc} \text{C} & & \frac{9}{8} & \text{D} & \frac{10}{9} & \text{E} & \frac{16}{15} & \text{F} & \frac{9}{8} & \text{G} & \frac{10}{9} & \text{A} & \frac{9}{8} & \text{B} & \frac{16}{15} & \text{C} \\ 1 & & \frac{9}{8} & & \frac{5}{4} & & \frac{4}{3} & & \frac{3}{1} & & \frac{5}{3} & & \frac{15}{8} & & 2 \end{array}$$

Chord lengths may be had by simply inverting the above fractions.

If, as is well known, we use, instead of these intervals, their logarithms, we have a set of numbers that may be compared by addition and subtraction and thus represent the actual magnitude of the intervals with a high degree of accuracy and convenience, especially for comparison with temperament.

The numbers 102, 91 and 56 are modified logarithms of the above fractions and may replace them—in which case 100 and 50 will respectively represent the two intervals of the tempered diatonic scale which is here given.

True scale	C	102	D	91	E	56	F	102	G	91	A	102	B	56 C
Tempered scale		100		100		50		100		100		100		50

It is further desirable to append the complete duodene of C as the most complete exhibition of all the tones and semitones of the octave as used.

B♭	D	F♯
E♭	G	B
A♭	C	E
D♭	F	A

This is taken from the English translation of Sensations of Tone by Helmholtz.

It is not considered necessary to explain these anew further than to remark that, in this tabular arrangement of the complete diatonic and chromatic scale, the intervals along the vertical lines are pure fifths, and along horizontal lines pure thirds. Thus their exact mathematical values are clearly established.

During the past century a number of efforts have been made to construct keyboard instruments such as the organ so as to meet the requirements of just intonation.

The problem has been considered an extremely difficult one especially as regards the piano, and the unsatisfactory mechanism heretofore devised has, in every instance, been practically rejected by the musical public, though every true musician would willingly sacrifice much to regain the inestimable beauty and purity of just intervals.

Helmholtz, Blaserna, and Taylor and a long line of able and eminent writers, have appropriately set forth the defects of tempered intonation, its tendency to obscure theory, and its blighting effects upon the essential beauties of music. But no instrument has been brought forward that seemed so attractive as the piano, with the licentious freedom of its tempered scales —and not a few have even grown into a cultivated disregard of its really great defects. But the tempered piano does not quite take rank among the best musicians. It is denied a place in the orchestra, and the most eminent vocalists and violinists accept it reluctantly for purposes of accompaniment. One writer even contemplates its final abandonment, along with tempered intonation, apparently never dreaming that its faults were capable of being remedied. Had it not been that it was already installed in almost every household, it is quite probable that even the complicated and cumbersome just intonation organs, that have been offered, would have won the day, and tempered intonation, the reproach of music, would have been, at this moment, only an unpleasant memory.

It would be foreign to the scope and purpose of this paper to enter into any extended discussion of the merits or demerits of tempered intonation, but it is freely granted that—though through long and dreary years, while voice and violin and orchestra were alone struggling for truth—music has on the one hand certainly suffered from its use, it has at the same time, though in an imperfect manner, filled a gap of some two centuries of almost hopeless waiting for better things.

And yet it has been by the piano and organ that the priceless gems of musical masters from Bach to Wagner have been brought, though in unworthy attire, into our daily lives and made our common property. Their rehabiliment in fitting garb has been the cherished desire of the writer and the results attained are indicated in this paper.

It has been fully realized from the very first, that such a work as the construction of a just intonation piano must deal very gently with existing methods and mechanism. It must change nothing, take nothing away, impose little or no additional exertion upon the player, be free from mechanical

defects and intricacies,—and last but not least, make light demands upon the purse.

The ordinary piano has, therefore, been taken as a foundation for the new, and without taking from the player his familiar instrument, he is enabled to instantly substitute, for its tempered harmonies, mathematically just intonation in twelve keys based on the twelve tempered chromatic intervals of the octave.

The changes from one to the other of these twelve justly intoned keys (each having its own complete chromatic scale), or back to temper again, is under the instantaneous control of the left foot, so that the right is left free to operate the dampers as usual.

The absolute uniformity of the tempered scale with its twelve equal intervals makes it admirably suitable as a basis for the necessary corrections, and its adoption as such essentially simplified the problem.

The modification of the evenly tempered intervals, to make them conform to those of true intonation, is effected by a line of small metallic movable bridges.

Each unison has a separate bridge which is capable of being moved toward the center of the string, thus shortening the vibrating portion and raising the pitch, or, it may, by a contrary motion, cause a depression of the pitch. When the instrument stands in temper the bridges will occupy the usual line of the agraffe, which is set back far enough to make room for them. Mechanism for the proper control of these bridges is placed on the top of the wrest plank and at the back of the piano and is actuated by intonation pedals which pass beneath, at the left of the center. When an intonation pedal is pressed, every bridge is instantly set, so as to give the mathematical cord length for its tone in that key, in which position it remains until reset by the same means.

In the instrument as at first constructed, there were thirteen pedals, representing the twelve just keys and the even temper. A much simpler and better arrangement has been since adopted.

Description of Parts.—Fig. 1 is a vertical section of part of a piano adjacent to one of the movable bridges, showing side elevation of string, movable bridge and parts related.

Fig. 2 is also a vertical section taken on the line X, at right angles to the section of fig. 1, and is drawn to a larger scale.

The string, or group of strings forming one unison, is shown at *a*, passes over the movable bridge *b* and the agraffe *g* to the wrest pin *f*.

The extreme phases of vibration of the string are shown by the dotted lines a' a''. The rod *e* is attached to the bridge *b*,

passes through an opening in the agraffe and between the wrest pins, and connects with the horizontal arm of lever (not shown) at the top of the wrest plank.

FIG. 1

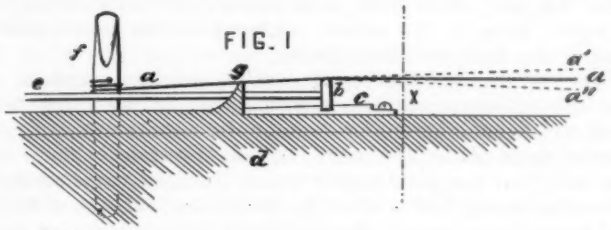
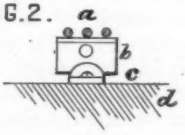


FIG. 2.



The movable bridge *b* has a concave bearing conforming to the convex surface of the slide, or way, *c*, so that the bridge may adjust itself to the plane of the strings constituting a unison and insure equal pressure of all the strings of the unison.

The slide *c*, upon which the bridge moves, has its upper surface parallel to the dotted line *a'*, thus equalizing the pressure of the string upon the bridge at all points and avoiding undue and unequal strain which would tend to put the piano out of tune.

At the top of the wrest plank is a series of lever arms actuating the bridges. By making these arms proportional to the strings to which they correspond, compensation is made for the varying lengths of the strings so that a given amount of motion (in arc) produces uniform change of pitch in all the strings.

These arms are attached to cylindrical rods which pass back to the rear of the piano where the other arm of each is attached at a right angle. The two arms and the connecting rod constitute a lever of which the cylindrical rod is the axis of motion.

The lever arms at the back are furnished with octave connections and on those pins are so placed that they are caught when a pedal is pressed and brought into that precise position that is required for the particular key that the pedal represents.

The entire just intonation mechanism including the eighty-eight bridges is made up of only two hundred and fifty movable parts, is not expensive nor difficult of construction, nor in any manner readily susceptible of derangement, but is durable and reliable to the last degree.

This construction is essentially different from all previous just intonation instruments in that *it acknowledges no tone cycles*, and consequently no compromise in intonation however small.

Each semitone of the tempered chromatic scale is in turn made the tonic or keynote of a separate just intonation scale of twelve tones to the octave, whose intervals correspond to those of the duodene given above.

This affords a complete and correct chromatic scale of just intervals besides a complete diatonic scale on the third below the tonic, whose seven tones bear the same relation to each other as those of the key itself. These same twelve tones comprise also four complete minor scales, founded respectively on the tonic, fourth, fifth and sixth, and having both the ascending and descending forms. Perfect triads, either major or minor, or both, are found upon all but one of the same twelve semitones, all without any change of intonation or use of pedals. But by using the pedals all these scales and chords may be duplicated on any one of the twelve tempered semitones as a tonic or key. Four dominant sept-chords, with resolutions on tonic triads a fifth below, should also be included in this estimate for each key. In addition to the twelve just keys as above, tempered intonation is always instantly available in response to pressure of a pedal.

These results summed up give one hundred and fifty-six tones to the octave, or eleven hundred and forty-four in the compass of seven and one-third octaves, against eight-eight in the ordinary piano.

The changes of tonality are practically instantaneous and can succeed each other in any order with great rapidity, if it were necessary, but the resources of a single key are so great that even in the most intricate music the pedal changes will be quite few. Many harmonies and progressions that would seem to involve foreign tones, do not require the use of the pedal at all but are found perfect and true, within the limits of the principal key in use at the time.

The way appears perfectly clear for the application of the same general principles to pipe and reed organs without increasing the number of pipes or reeds.

The result of familiarity with just intervals during the work of construction and since the satisfactory completion of the instruments now in use at my home in Cincinnati, fully confirms all that Helmholtz and others have said as to the inexpressible sweetness and beauty of pure harmonics.

Their clearness renders all music more intelligible as well as agreeable, the musical sense is rapidly rendered more acute, and tone perception and tone production matters of much

greater ease and precision, and as a natural consequence, tempered intonation, and errors of tuning generally, rendered more and more intolerable.

While any composition is greatly enhanced in beauty, there runs through all—even bits of melody, simple chords, or scales —a restful, satisfying effect that could hardly be conceived without the actual experience.

It is the profound conviction of the writer that just intonation in music is of the greatest importance.

Persons listening to the best orchestras often imagine that they are hearing it in its perfection. This is far from being true. Temperament has leavened it also, as is capable of abundant proof.

As Helmholtz remarks—few modern musicians have ever heard tone intonation, and consequently its superiority over temperament is greatly underrated.

Cincinnati, O.

Art. XIX.—*Very on Atmospheric Radiation*;* by William Hallock.

It will require no long consideration to recognize that the question of atmospheric radiation and absorption is one of fundamental importance in meteorology, and an equal reflection will convince any physicist of experience of the extreme complexity and difficulty of the search for its answer.

The problem is naturally divided into two parts: First, the absorption, transmission and re-radiation by the atmosphere of that energy which reaches it direct from the sun; that is, from a source at a very high temperature. Second, the absorption, transmission and re-radiation of the energy which comes to the atmosphere from terrestial sources; that is, from a source at medium temperatures. The curve of distribution of energy with reference to wave length is radically different in the case of the two sources, the maximum for the sun lying in much shorter wave lengths than in that for the earth. Here at the outset is the difficult necessity of considering not only the total absorption or radiation, but its distribution as to wave length. Add to this the presence of water vapor in varying relative humidity, and absolute quantity, and of CO_2, and trouble enough is at once apparent.

Such a research as this is one properly suited to the resources of a Government Bureau, where a long series of exhaustive investigations may be carried on uninterruptedly by a competent physicist, with liberal provision for all money needed for expensive apparatus. In the present case the physicist alone with his zeal, and but little money, seems to have been relied upon to solve the riddle.

Prof. Very has carried out, with much skill and industry, a highly laborious piece of experimental work, and this, with his theoretical discussions, certainly constitute a most valuable contribution to this important subject. At the same time, no one better than he, can realize the still outstanding doubts which cluster about the subject, and which leave the final solution of the problem still indefinite.

Naturally the bolometer was chosen as the measuring instrument, since Prof. Very had already had such valuable experience with it. The Boys radio-micrometer or the Nichols radiometer would have been more sensitive, but too often added delicacy is purchased at the expense of serious disturbances and errors.

In "Method A," fig. 1, two masses of air at different temperatures, confined in long tubes with open ends, were alternately interposed between a concave mirror and the bolometer

* Atmospheric Radiation: a Research conducted at the Allegheny Observatory and at Providence, R. I.: submitted to Willis L. Moore, Chief U. S. Weather Bureau, by Frank W. Very. Pp. 134, 4to, Washington, 1900—Bulletin G, Weather Bureau, No. 221 (U. S. Dept. of Agriculture).

placed at its center of curvature. The concave mirror was of slightly larger angular aperture than the bolometer case and was kept at a constant temperature. The difficulties of manipulation and the comparatively small effect due to the differences of temperature of the air rendered this method unsatisfactory.

1

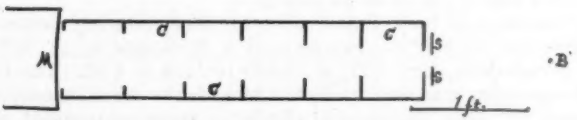


FIG. 1, diagram of "Method A." M is a concave spherical mirror, concentric with the bolometer strips at B. S S is the last screen in the opening of the bolometer case. C C C is one of the two air tubes interposed between the mirror and the bolometer.

Considerable valuable data was obtained by "Method B," where a vertical current of air of varying rectangular cross section and temperature was made to rise in front of the bolometer. The air current always subtended a greater angle than the aperture of the bolometer case. This method is similar to that used by Hutchins,* whose conclusion that "radiation only takes place when there is a fall of temperature within the limits of molecular action" appears to Prof. Very not altogether warranted. In this method the investigator is confronted with the question as to what extent a part of the radiating mass of air absorbs the radiations from another part. There can be no doubt that this takes place and that nothing is gained by increasing the thickness of the mass beyond a certain limit. It must not be forgotten, moreover, that this absorption is selective and does not affect all wave lengths equally (cf. fig. 4).

2

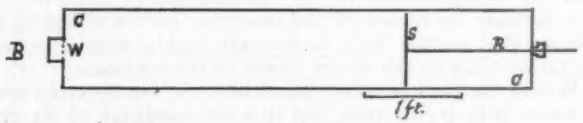


FIG. 2, diagram of "Method C." C C is the air-tight cylinder. S is the disk which can be moved near to, or far from, the rock-salt window W, by means of the rod R, which runs through a stuffing box. The bolometer is located at B.

Perhaps the most satisfactory contributions were made by "Method C," fig. 2. In this case an air-tight cylinder, five feet long and one foot in diameter, was provided with a rock-salt window at one end, and a stuffing box at the other. Through the latter ran a rod carrying a disk on its inner end which nearly

* This Journal, vol. xliii, p. 357, May, 1892.

filled the cross-section of the cylinder. This disk was supposed to remain at the same constant temperature as the gas, a greater or less thickness of which was allowed to radiate out the salt window, according as the disk was near to, or far from, that end of the cylinder. This apparatus, if it had been tight and provided with thoroughly satisfactory means of heating, would have given even better results than it did. By these means the effect of varying temperatures and pressures, relative humidities, and carbonic acid gas could be determined.

For example, it was found that for atmospheric pressure and temperatures to 100° C. excess, and a thickness of 141·8^{cm}, the ratio of radiation, air : CO_2 = 0·1885 / 0·1254 = 1·50. The radiation from steam was also tried, but the results were inconclusive. "Method D" used the above cylinder to store compressed gases, which after being heated in going through a hot brass tube were caused to pass in front of the bolometer. In this way the relative radiation of air and steam, and clear and smoky air, were studied. It appears that steam under certain conditions radiates at least four times as much as air, and that the presence of condensed particles of water does not seriously affect the results. A limited series of experiments seemed to show that the presence of fine particles in the air, as in smoke, did not affect its radiation.

It is manifestly impossible to refer ever so briefly to the mass of details and discussions; they must be studied in the original. When we consider how much material for study is here presented, and that too many government scientific publications are simply narrations of undigested details, without proper consolidation and abstraction, we must be grateful to Prof. Very for summarizing his work as well as its extreme complexity will admit. Nevertheless it will only be practicable to extract here a few sentences:

"The direct effect of the sun's rays is less on a normal surface in the tropics than in temperate regions, and less at sea level than upon a mountain top, owing to the difference in the aqueous component of the air; and the ability of the solar radiation to maintain a high temperature in the torrid zone or at sea level is due to the accumulation of the thermal energy imparted to the earth's surface by reason of the retention of the escaping radiation from that surface by a moist and highly absorbent atmosphere rather than to the direct power of the sunbeam." (P. 125.)

"'Where the land is moist the changes in temperature are less than where it is dry or arid,' but it is the condition of the air and not that of the soil which makes the radiation possible or impossible." (P. 127.)

"Within moderate depths of only a few meters the radiation of dry air, purified from carbon dioxide, increases quite uniformly with the depth; the radiation of a 1-meter layer of purified air at 50° C. and near atmospheric pressure (735^{mm}) as compared with one at 0° C., is 0·00068 radim, representing a transformation and transfer of thermal energy of 0·00068 small calories every second through each square centimeter of limiting surface; the

radiation of a like depth of carbon dioxide at the same temperature is three and one-half times that of air, or 0·00238 radim,

3

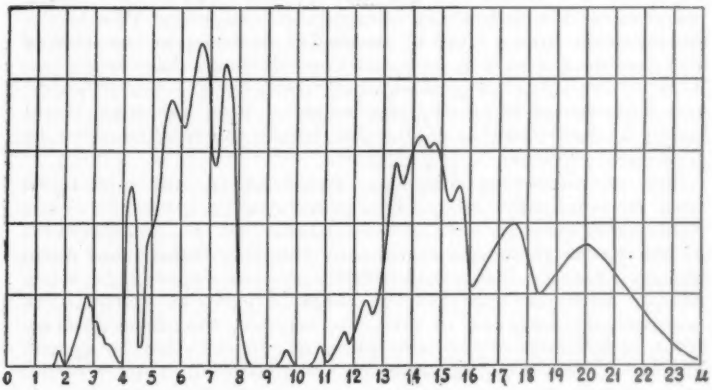


FIG. 3. Approximate spectral energy-curve of air radiation, for moist air at 50° C. Wave-lengths laid off as abscissæ.

4

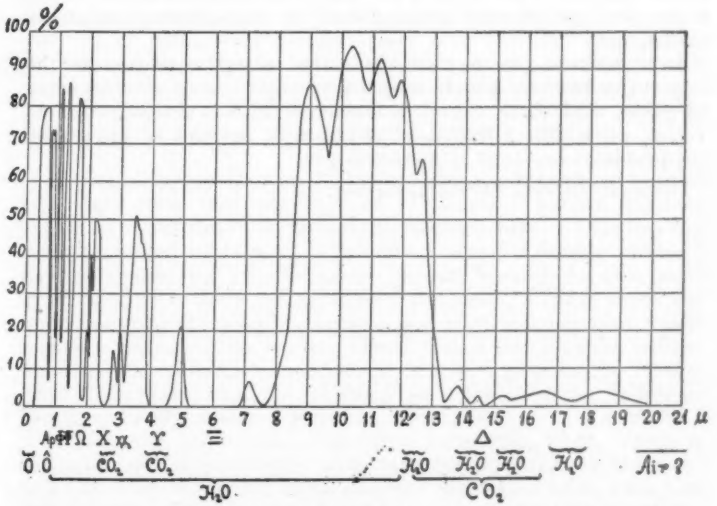


FIG. 4. Curve of transmission of radiation by the earth's atmosphere. Wave-lengths as abscissæ and percentage transmission as ordinates. The probable cause of the absorption band is indicated in each case.

which is very nearly a maximum for this temperature, further increase of the radiant depth being unattended by a corresponding addition of radiant energy, showing that equilibrium between radiation and emission has been almost reached at this depth; the radiation from a layer of steam five feet deep at one-sixth of atmospheric pressure is two and one-half times that from a like body of dry air at temperatures near the boiling point of water, and eight-tenths of the radiant emission from the black solid body; while for smaller depths the radiant power of water vapor is relatively greater." (P. 129.)

The accompanying diagrams, figs. 3 and 4, are reproduced from the summary. Fig. 3 is a provisional energy-curve of the radiation of moist air for the temperature $+50°$ C. The positions of the bands (from observations by Paschen, Rubens and Aschkinass) relate to the emission from aqueous vapor and carbon dioxide with the exception of those of extreme wave length provisionally assigned to nitrogen, oxygen, etc., from observations by Hutchins of the absorption of air radiation by quartz. Fig. 4, the curve of transmission of radiation by the terrestrial atmosphere, relates to a vertical transmission through a clear air of moderate humidity, and shows the general fact of selective absorption scattering of short waves with the progressive strengthening of band absorption in the infra-red, due to the gases indicated (mainly water vapor), to finally a region of almost total absorption provisionally attributed to the permanent gases of the atmosphere.

In conclusion, it may not be amiss to call attention to the important bearing which recent investigations on electrification of gases, and their electrical behavior under the influence of violet, ultra-violet, Becquerel and X-rays, is sure to have upon the problems involved in meteorology.

Columbia University, Physical Laboratory.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Radio-active Lead.*—Those substances that emit the remarkable rays discovered by Becquerel have heretofore been found associated with the uranium, thorium, barium, bismuth and titanium extracted from minerals containing uranium and thorium. Hofmann and Strauss have recently found active properties in lead salts obtained from such minerals, viz., pitchblende, cleveite, bröggerite, uranium mica, samarskite and euxenite, and they believe that they have evidence of the existence of a new element which resembles lead in many ways, but is quite different from that metal in other respects. The substance, like lead, gives a sulphide which is insoluble in dilute acids and in ammonium sulphide, and a sulphate insoluble in dilute sulphuric acid. The chloride is more readily soluble than lead chloride in pure water. In the spark spectrum occurs a violet line which does not belong to lead. The equivalent weight of the substance is very different from that of lead, and the valency seems to be higher, since the sulphate liberates iodine from an acidified solution of potassium iodide. The authors think it probable that the element in question is bivalent and quadrivalent and has an atomic weight of over 260. The chloride and especially the sulphate fluoresce under the action of cathode rays, and they thus acquire the property of acting upon the photographic plate in the dark. It is only after some months that they lose this activity, which approaches in intensity that of the most active thorium or uranium preparations. The present communication is merely a preliminary notice, and further publications promised for the near future will be awaited with interest.—*Berichte*, xxxiv, 8.

H. L. W.

2. *Physiological Action of Radium Rays.*—It has been noticed by Walkhoff that the rays of radio-active barium produce inflammation of the skin, similarly to Röntgen rays. This fact has been confirmed by Giesel. The latter placed a double celluloid capsule containing ·27 g. of active barium bromide for two hours in contact with the inner surface of the arm. At first there was only a slight reddening of the skin, but after three or four weeks a severe inflammation set in. Giesel found also that the radium rays exert a similar action upon the leaves of plants; the chlorophyl disappears, and the exposed part takes on the yellow or brown color of autumn.—*Berichte*, xxxiii, 3569. H. L. W.

3. *Chlorine Heptoxide.*—This new substance, Cl_2O_7, which is the anhydride of perchloric acid, has been prepared by Michael and Conn by the action of phosphorus pentoxide upon pure perchloric acid. The reaction is a dangerous one on account of the explosive nature of the product, and must be carried out very gradually at a temperature of —10°. Chlorine heptoxide is a

colorless, very volatile oil, boiling at 82°. On standing a day it begins to turn yellow and after two or three days it is greenish yellow and gives off a greenish gas. When brought into contact with flame, or by a sharp percussion, it explodes with great violence, but in comparison with other oxides of chlorine it shows great stability, and it may be poured on paper, wood or similar organic matter with impunity, the oxide simply volatilizing in the air.—*Am. Chem. Jour.*, xxiii, 444. H. L. W.

4. *The Non-Existence of Trivalent Carbon.*—In a recent number of this Journal (vol. x, p. 458) mention was made of the supposed existence of triphenylmethyl, $(C_6H_5)_3C$, which would show the existence of trivalent carbon. J. F. Norris has now discovered facts which furnish an adequate explanation of Gomberg's results without the necessity of introducing any new principles. He believes that the compound formed by the action of zinc upon triphenylchlormethane is probably diphenylphenylenemethane, $(C_6H_5)_2C{:}C_6H_4$, an atom of hydrogen being removed along with the chlorine atom. In spite of this new aspect of the matter, Gomberg's results possess great interest. The trivalent carbon formula was advanced merely as a preliminary suggestion.—*Am. Chem. Jour.* xxv, 117. H. L. W.

5. *Diffusion of Gold in Solid Lead at Ordinary Temperature.*—By placing cylinders of solid lead upon disks of gold for a period of four years at a nearly constant temperature of about 18°, Sir W. C. Roberts-Austin has found that gold passed into the lead. In the lowest layer of $\cdot 75^{mm}$ gold was present to the extent of 1 oz. 6 dwt. per ton, while in a slice 7^{mm} from the surface of contact there were found 1½ dwt. per ton. It is calculated that the rate of diffusion is about 1/350,000 of that in molten lead.—*Jour. Chem. Soc.*, lxxx, II, 9. H. L. W.

6. *On Cerium.*—The opinion expressed in recent literature that cerium consists of at least two elements, is shown to be in all probability without foundation by a careful investigation on the large scale by G. B. Drossbach. 250 kilograms of commercial cerium carbonate were subjected to a long series of operations in order to remove impurities, and finally double salts of cerous nitrate with ammonium nitrate were subjected to systematic fractional recrystallization. In the course of seven months more than two hundred crystallizations were made, and fractions widely separated from one another showed no differences from cerium preparations which could be obtained by the careful use of older methods of purification. The cerium dioxide obtained by igniting cerium nitrate in all cases showed a pale yellowish tint.—*Berichte*, xxxiii, 3506. H. L. W.

7. *A Method for Crystallizing Substances without the Formation of Crusts upon the Surface of the Liquid.*—When a substance is crystallized by the slow evaporation of its solution, crusts are often formed at the surface, and as evaporation continues from such crusts, any impurities that the liquid may contain are likely to be enclosed and thus contaminate the product.

A. WRÓBLEWSKI has devised a method of evaporation by which this difficulty is overcome. He places the solution from which crystals are to be obtained in a cylinder the bottom of which is closed with a parchment membrane, while the top is corked and provided with a water trap. Evaporation takes place through the membrane the lower side of which is exposed to air artificially dried with calcium chloride. In the case of readily diffusible salts a certain amount of dry crystals is formed upon the external surface of the membrane, but this does not take place with dilute solutions. Crystallization takes place within the cylindrical vessel without the formation of crusts. The method is particularly recommended for the crystallization of proteids.—*Zeitschr. physikal. Chem.*, xxxvi, 84. H. L. W.

8. *On the velocity of the ionized phosphorus emanation in the absence of electric field*; by C. BARUS. (Communicated.)—In Science (Feb. 9, 1900) I communicated a series of data on the absorption of the emanation from phosphorus, in tubes of different diameter ($2r$) and material. I have since brought my results together and am now able to compute the velocity, k, of the ionized particle absolutely. I find $k = 2{\cdot}65\,(V/rx)\,ln\,V/V_0$, where V and V_0 are the liters per minute of air saturated with phosphorus emanation needed to retain a field of constant color in the steam tube, for lengths x and zero, respectively, of the absorption tube of radius r.

The results are for tubing of gray rubber, $2r = {\cdot}64^{cm}$, $k = {\cdot}28^{cm}$/sec; pure rubber, $2r = {\cdot}35^{cm}$, $k = {\cdot}32^{cm}$/sec; lead, $2r = {\cdot}63^{cm}$, $k = {\cdot}25^{cm}$/sec; lead, $2r = {\cdot}32^{cm}$, $k = {\cdot}30^{cm}$/sec; glass, $2r = {\cdot}29^{cm}$, $k = {\cdot}27^{cm}$/sec. These data show no relation to diameter or material. I conclude that the ionized region is under a kind of osmotic pressure such that for highly saturated phosphorus emanation the velocity of particles is about 3 millimeters per second. This small velocity, it will be noticed, is associated with large viscous resistances, so that the pressures are not necessarily small.

9. *The Thermo-chemistry of the Alloys of Copper and Zinc*; by T. J. BAKER, B.Sc., King Edward's School, Birmingham. Read January 17, 1901, before the Royal Society of London.* (Abstract.)—The heats of formation of a number of alloys of copper and zinc, containing those metals in very diverse proportions, have been ascertained. The method consists in finding the difference between the heats of dissolution, in suitable solvents, of an alloy and of an equal weight of a mere mixture containing the metals in the same proportion.

The first series of experiments was made with an aqueous solution of chlorine as solvent. Its application was limited to those alloys containing less than 40 per cent of copper, as it was impossible to obtain those richer in copper in a sufficiently fine state of division to enable them to dissolve. The results, though not altogether satisfactory, showed that the heat of dissolution of an

* Advance proof from the author.

alloy was sensibly less than that of the merely mixed metals. Incidentally it was found that the equation $Cl_2.Aq = 2{,}600$ (Thomsen's "Thermochemische Untersuchungen") is erroneous and, on inquiry, Professor Thomsen gave a corrected value, 4,870. The author finds $Cl_2.Aq = 4{,}970$.

The most suitable solvents of the alloys are—

(*a.*) Mixture of ammonium chloride and ferric chloride solutions.

(*b.*) Mixture of ammonium chloride and cupric chloride solutions.

The chemical actions involved are simple reductions, and no gases are evolved.

Two series of experiments made on twenty-one alloys yielded very concordant results. They show that heat is evolved in the formation of every alloy of copper and zinc yet tested. A sharply defined maximum heat of formation is found in the alloy containing 32 per cent of copper, i. e., corresponding to the formula $CuZn_2$. It amounts to 52·5 calories per gram of alloy or 10,143 calories per gram-molecule. There is some evidence of a sub-maximum in the alloy nearly corresponding to CuZn. From these points there is a steady decrease in the heat of formation, both in the case of alloys containing less than 32 per cent of copper as the amount of copper decreases, and also in the case of those containing more than 50 per cent of copper as the quantity of copper increases.

The results, in general, confirm the existence of intermetallic compounds, and the values obtained are in accordance with those demanded by Lord Kelvin's calculation of the molecular dimensions of copper and zinc.

10. *On the decrement of electrical oscillations in charging condensers.*—This paper is the work of two authors. A. F. Sundell has worked out the theory and Hj. Tallquist the experimental appliances. It was found that after a relatively short time reckoned from the beginning of the charging the capacity of a mica condenser reached the same value under oscillatory charges as under direct charges. The method also give a means of determining self-induction.—*Ann. der Physik.*, No. 1, 1901, pp. 72–98. J. T.

11. *Effect of a magnetic field on the discharges through a gas.*—Dr. R. S. Willons concludes from his experiments that at pressures below $\cdot 5^{mm}$ the magnetic field decreased the electric force near the cathode; this decrease depended upon the strength of the field and the current. At higher pressures the magnet increased the electric force. If the magnet caused the column to striate it also caused the electric force to show periodic striations. The magnet generally caused the electric force at the anode to increase.—*Phil. Mag.*, pp. 250–260, Feb. 1901. J. T.

12. *Conductivity produced in gases by the motion of negatively charged ions.*—Professor Townsend, of Oxford, England, had previously shown that negatively charged ions moving through

a gas produce other ions, although the force acting on them is small compared with the force necessary to produce the ordinary vacuum discharge. (Nature, vol. lxii, Aug. 9, 1900.) In the present paper, he gives a more complete account of his investigations, and he is led to the conclusion that there is a great difference between the positive and the negative ions at low pressure, and that the negative ions are much smaller than molecules. There is not much difference between the rate of diffusion of the positive and negative ions. The slow rate of diffusion may be due to the negative ions being carried in groups of molecules, and the rates of diffusion of positive and negative ions would depend upon the size of such groups. When the current passes between two electrodes, one inside the other, the conductivity, when the electromotive force is small, is unaltered by reversing the current. When this force is large, the conductivity depends greatly on the direction of the force. The current obtained from the inner positive electrode may be five or ten times greater than that obtained when the inner electrode is negative. The reason appears to be due to collisions if we attribute the production of new ions to the negative ions. In order that new ions should be produced by collisions, it is necessary that negative ions should pass through the gas near the inner electrode where the force is large. When the inner electrode is positive, all the negative ions pass through this region, and a large conductivity is obtained. When the inner electrode is negative, only a few of the negative ions pass through the space where the force is large and the conductivity is much reduced. The increase in conductivity is due to the negative ions, and not to the positive ions. The positive and negative ions therefore possess different physical properties.—*Phil. Mag.*, pp. 198–227, Feb., 1901. L. T.

13. *Recueil de Données Numériques publié par la Société Française de Physique. Optique par* H. DUFET. Troisième Fascicule, pp. 787–1313, with volume title page and contents. Paris, 1900 (Gauthier-Villars).—This highly valuable compilation of physical data (see this Journal, vii, 472) has now reached its Third Part, which completes the volume on Optics. It contains the following tables: Table XVII, Rotary Power of Crystalline Bodies, including chiefly quartz and sodium chlorate; also other crystallized substances. Table XVIII, Rotary Powers of Bodies, liquid or dissolved; also those of vapors. Table XIX, Interference Colors, according to Newton, Wertheim, Quincke, and Rollet. These tables are complete to the close of 1898. A Supplement, pp. 1173–1305, brought down to the end of December, 1899, contains tables of wave-lengths; of refractive indices for gases, liquids, and various important solids, etc. The whole is printed with great clearness and full references are given to the original authors.

14. *One Thousand Problems in Physics;* by WILLIAM H. SNYDER and IRVING O. PALMER. Pp. 142. Boston, 1900: Ginn & Co.—This little volume contains well selected problems, especially suited to the use of teachers of Physics in the secondary schools.

II. Geology and Mineralogy.

1. *Maryland Geological Survey: Allegheny County;* Wm. Bullock Clark, State Geologist. Pp. 1–323, plate i–xxx, figures 1–15, with Folio Atlas, 1900.—"The present volume on Allegheny County inaugurates a new series of reports dealing with the physical features of the several counties of Maryland. Not only the geology and mineral resources of Allegheny County will be considered but also the physiography, soils, climate, hydrography, magnetic declination, forests and life characteristics." This is a tempting program and will attract the interest of readers, as will the beautiful illustrations and fine appearance of the volume.

The following list of formation names is adopted and preliminary descriptions of them are given:

Cenozoic.	
Pleistocene	Alluvial, etc.
Paleozoic.	
Permian	Dunkard.
Carboniferous	Monongahela
	Conemaugh
	Allegheny
	Pottsville
	Mauch Chunk
	Greenbrier
	Pocono
Devonian	Hampshire
	Jennings
	Romney
	Oriskany
	Helderberg
Silurian	Salina
	Niagara
	Clinton
	Tuscarora
	Juniata

In the absence of paleontological evidence we shall watch with interest for the reasons for accepting the Niagara as one of the formations of the series in this State. And the geological reader will wonder on what basis the name Salina is applied to the rocks so described in the report, and also on what grounds the 400 feet of rocks "corresponding to the Tentaculite limestone of New York" are separated from the so-called Salina and included in the "Helderberg formation," which is made the base of the Devonian. W.

2. *United States Geogolical Survey.* C. D. Walcott, Director.—The following publications of the Survey, bearing the date 1900 and for the most part not hitherto noticed, have been received, viz:

Monograph. XXIX. The Eocene and Lower Oligocene Coral Faunas of the United States, with Descriptions of a Few Doubtfully Cretaceous Species, by T. Wayland Vaughan. 263 pp., 24 pl. [To be noticed later.]

Bulletins—

163. Flora of the Montana formation, by Frank Hall Knowlton. 118 pp., 19 pl.
164. Reconnaissance in the Rio Grande Coal Fields of Texas, by Thomas Wayland Vaughan, including a Report on Igneous Rocks from the San Carlos Coal Field, by E. C. E. Lord. 100 pp., 11 pl. and maps.
165. Contributions to the Geology of Maine, by Henry S. Williams and Herbert E. Gregory. 212 pp., 14 pl.
166. A Gazetteer of Utah, by Henry Gannett. 43 pp., 1 map.
167. Contributions to Chemistry and Mineralogy from the Laboratory of the United States Geological Survey; Frank W. Clarke, Chief Chemist. 308 pp.
168. Analyses of Rocks, Laboratory of the United States Geological Survey, 1880 to 1899, tabulated by F. W. Clarke, Chief Chemist. 308 pp.
169. Altitudes in Alaska, by Henry Gannett. 13 pp.
170. Survey of the Boundary Line between Idaho and Montana from the International Boundary to the Crest of the Bitterroot Mountains, by Richard Urquhart Goode. 67 pp., 14 pl.
171. Boundaries of the United States and of the Several States and Territories, with an Outline of the History of all Important Changes of Territory (Second Edition), by Henry Gannett. 142 pp., 53 pl.
172. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1899, by Fred Boughton Weeks. 141 pp.
173. Synopsis of American Fossil Bryozoa, including Bibliography and Synonymy, by John M. Nickles and Ray S. Bassler. 663 pp.
174. Survey of the Northwestern Boundary of the United States, 1857–1861, by Marcus Baker. 78 pp., 1 pl.
175. Triangulation and Spirit Leveling in Indian Territory, by C. H. Fitch. 141 pp., 1 pl.
176. Some Principles and Methods of Rock Analysis, by W. F. Hillebrand. 114 pp. W.

3. *Geological Survey of Michigan.* ALFRED C. LANE, State Geologist. Vol. vii, Part III; *Geological report of Sanilac County, Michigan;* by C. H. GORDON. Pp. 1–34, 5 Plates, 2 figures. 1900.—The rocks met with in Sanilac County, together with those of Monroe and Huron Counties, described in parts I and II, represent all the formations of the lower Peninsula although these counties are situated in the southeast corner of the State. Part I, vol. viii; *Clays and Shales of Michigan, their Properties and Uses;* by H. RIES. Pp. 67, with four plates.

This volume, edited by the State geologist, Prof. Alfred C. Lane, contains the results reached by Dr. Ries in examining the clays of Michigan. An account is given of the various localities and also of the tests to which the clays from them have been subjected.

W.

4. *The Geological and Natural History Survey of Minnesota. The Twenty-fourth (and final) Annual Report for the years 1895–1898.* N. H. WINCHELL, State Geologist. 1899. Pp. 1–284.—The main body of this report consists of lists and notes of rock samples, record of the field work, and indices, but the introductory statement by the State Geologist is of special interest. A brief review of the history of the Survey during its 27 years is given. The Salt Spring lands of the State were early set apart to be used for the prosecution of the Survey. The State Geologist estimates that through the agency of the State Geologist, indemnity lands to the amount of 19,872 acres were discovered; these were transferred by the Legislature of 1885 to the Board of Regents for the purpose of a Geological and Natural History Survey. The Geological Survey of Minnesota has therefore been endowed by grants of land, 18,771 acres of the Salt Spring lands and 19,872 acres in 1885, making a total of 38,643 acres.

The total cost of the Survey from 1872 to July 31, 1899, is estimated to be $146,357.27. "The total revenue to the State as shown in dollars that can be counted, in excess of the public good that may come from the Survey," is claimed to be $132,609.26.

The State Geologist is to be congratulated that he can make so good a showing for his administration of the Survey of his State.

W.

5. *The Pleistocene Geology of the South Central Sierra Nevada with Especial Reference to the Origin of Yosemite Valley;* by HENRY WARD TURNER.—Proceedings of the California Academy of Sciences, 3d Series, Vol. i, No. 9, pp. 262–321, with 9 plates.—As an introduction to the discussion of the origin of Yosemite Valley, Mr. Turner reviews the orogenic movements of the Sierra Nevada region and describes three pleistocene periods, Sierran, Glacial and Recent. There is no common opinion regarding the importance of glacial work in the formation of the valleys of the Sierras. John Muir ascribes the topography of the entire mountain system from base to summit to the work of glacial ice. Prof. Whitney doubted the existence of any glaciation in the region. Other writers have held intermediate positions. Because of this wide variation in opinion, Turner has critically reëxamined the evidence regarding the erosive power of ice, the origin of rock basins and glacial cirques with special reference to the Sierras. He concludes that "the theory that great canyons or even considerable ravines are formed by the gouging action of ice does not seem supported by the evidence," and that ice erosion has not been a controlling factor in the formation of Yosemite. That this valley is the result of a drop fault was held by Whitney, Reyer and Russell. The rocks, however, in general show no faulting

structures and it is quite improbable that a *graben* 4,000 feet deep would be so short and end so abruptly. Moreover, the steep walls which suggest faulting are satisfactorily explained by the system of vertical joints. Turner's investigations support the views of Becker and Branner that the Yosemite Valley "was formed by river erosion facilitated by strong jointing," just as are many other canyons of the Sierras. "That some faulting has occurred along the sheeted or jointed zones of granite about the Yosemite is probable, but it is thought that this has resulted rather in a more thorough shearing of the granite than in the dropping down of wedges. Along such a sheared zone, the streams would rapidly deepen their beds. Even where the rocks are not sheared, but merely intersected with vertical joints, it is easy to see how, as erosion progressed, the slabs would crumble or tumble off along the joint planes, leaving vertical faces. If now a tongue of ice should pass through the valley and clear out the talus and other detritus and round off the projecting shoulders and spurs, and as it retreats leave terminal moraines as barriers to form the valley floor, we seem to have sufficient means for the accomplishment of all we now see in Yosemite Valley." (Pp. 319–320.) H. E. G.

6. *Geologishes Centralblatt; Anzeiger für Geologie, Petrographie, Palaeontologie, und verwandte Wissenschaften;* edited by K. KEILHACK. Vol. I, No. I, 32 pp., 8°. Leipzig (Gebrueder Borntraeger).—This new journal has for its object the prompt publication for those interested of brief abstracts of all important contributions in geology and its allied sciences. A special endeavor to accomplish this with the least possible delay is promised. The abstracts will appear in German, English and French. In addition to the editor-in-chief, the names of seventy-eight geologists, from all parts of the world, are given who will aid in conducting the journal. The numbers are to appear every two weeks. There can be no doubt that a publication of this kind, if well carried out, will prove highly useful, and we wish it all success. L. V. P.

7. *Metasomatic Processes in Fissure Veins;* by WALDEMAR LINDGREN. (A paper read before the American Institute of Mining Engineers, Feb., 1900. Author's edition.)—The purpose of the paper, as expressed in the author's own words, is to collect the scattered data relating to the alteration of rocks near fissures, to indicate the principal active processes, to classify the veins, if possible, according to the different phases of alteration accompanying them, and finally to draw some conclusions from the facts thus grouped. In Part II of his paper Mr. Lindgren discusses the various minerals developed by metasomatic processes in mineral veins, giving the origin, mode of replacement, etc. In Part III he proposes fourteen different classes into which fissure veins may be divided, naming each class according to the principal metasomatic process found in it. Each class is discussed and examples cited. For instance, Class No. 8 is that of Sericitic

and Calcitic Gold Silver Veins, and is illustrated by the gold quartz veins of California. Some of the conclusions of the paper are as follows: Almost all fissure veins are bordered by altered zones, the character of the alteration differing widely in different veins; that the alteration usually consists in the loss of certain constituents and the introduction of new elements, chiefly CO_2 and S; that the processes are such as can only be explained by aqueous agencies acting under high pressure, temperature and concentration while ascending along the fissure; that these ascending waters are chiefly surface waters which after a circuitous underground route have found in a fissure an easy way to return to the surface; and that most fissure veins are genetically connected with bodies of intrusive rock which on cooling give off volatile compounds of the heavy metals which on sizing meet surface waters and are carried along by them and subsequently deposited by their aid in the veins. W. E. F.

8. *Some Iowa Dolomites;* by NICHOLAS KNIGHT. (Communicated.)—The rocks herein described were analyzed in the chemical laboratory of Cornell College under the direction of the writer. The composition of the rocks varies from nearly typical dolomite to admixtures in different proportions of calcium carbonate and dolomite.

(1.) This is a bluish-drab saccharoidal rock, situated near the base of the Iowa Devonian series, at Rochester, Iowa. It is of special interest because locally believed to contain silver. A miner's shaft, thirty feet deep, has been sunk to it, and several analyses are said to have been made, showing a large amount of silver. Professor W. H. Norton, of the Iowa Geological Survey, was unable to authenticate any of the analyses. He found no geological grounds for the slightest suspicion of any precious metal in these beds. This analysis was made not to disprove the presence of silver, but to show the lithological change from the subjacent dolomites of the Silurian. The specimen was analyzed by Miss Minerva Herrinton, A.B.

$CaCO_3$	78·75	per cent
$MgCO_3$	20·16	"
Fe_2O_3 and Al_2O_3	0·10	"
SiO_2	0·4	"
MnO_2	0·2	"
	99·61	"

The rock varies widely from a true dolomite, which contains $CaCO_3$ 54·35, $MgCO_3$ 45·65.

(2.) The Coggon beds as described by Professor Norton in the Reports of the Iowa Geological Survey, overlie the Gower stage of the Silurian, and are immediately beneath the Otis beds of the Wapsipinnicon stage,—the lowest Devonian terrane recognized in Iowa. The lithological affinities of the Coggon are with the Niagara, but the very meager fauna inclines rather toward the Onondaga limestone of the Devonian. The specimen from

Bieler's quarry in Cedar County, Iowa, was analyzed by Miss Herrinton.

$CaCO_3$	58·2	per cent
$MgCO_3$	39·5	"
Fe_2O_3 and Al_2O_3	0·9	"
SiO_2	1·2	"
	99·8	"

This is not a true dolomite but more nearly approaches it than the rock described in 1.

(3.) The Gower stage as defined by Professor Norton includes two distinct lithological types: a hard crystalline rock used extensively for lime and hitherto known as the Le Claire limestone; and a granular evenly-bedded rock which furnishes the best building stone in the State. This was, until recently, designated as the Anamosa beds, which have usually been assigned rank as a distinct geological formation; but the Iowa Geological Survey, in its recent reports, has taken them to be but a lithological phase of one formation. The name *Gower* has been assigned them from the township in Cedar County in which the important Bieler quarries are situated. Both types of rock are found in the Bieler quarries. The following specimen of the granular laminated building stone was analyzed by Miss Herrinton. It varies only slightly from a true dolomite.

$CaCO_3$	56·4	per cent
$MgCO_3$	42·6	"
Fe_2O_3 and Al_2O_3	0·7	"
SiO_2	0·4	"
	100·1	"

(4.) Specimen of the Gower phase taken from the Mount Vernon quarry. It was analyzed by Mr. E. A. Rayner.

$CaCO_3$	54·02	per cent
$MgCO_3$	44·73	"
Fe_2O_3 and Al_2O_3	0·61	"
SiO_2	0·29	"
	99·65	"

The rock is nearly a typical dolomite.

(5.) The rock at the Palisades, on the Cedar River, six miles distant from Mount Vernon, is similar in composition to the Mount Vernon rock. It is stratified but not granular. Building stone occupies layers adjacent to others which are burned for lime. The specimen was analyzed by Mr. G. R. Greaves.

$CaCO_3$	53·64	per cent
$MgCO_3$	43·89	"
Fe_2O and Al_2O_3	0·52	"
SiO_2	1·98	"
	100·03	"

(6.) This is of the same type as (3). It is a finely laminated building stone, but crystalline instead of granular. The specimen analyzed by Miss Herrinton is from the large quarries at Lime City, Iowa. It is nearly a dolomite in composition.

$CaCO_3$	55·3	per cent
$MgCO_3$	43·0	"
Fe_2O_3 and Al_2O_3	1·4	"
SiO_2	0·6	"
	100·3	"

(7.) This is also a representative of the Gower limestone and of the Le Claire lithological phase. The specimen was taken from a ledge on Rock Creek, two and a half miles southwest of Tipton, Iowa. The ledge is notable for its exceptionally high dip, reaching 70°. It varies but little from true dolomite. The analysis was made by G. R. Greaves.

$CaCO_3$	55·76	per cent
$MgCO_3$	43·85	"
Fe_2O_3 and Al_2O_3	0·26	"
SiO_2	0·12	"
	99·99	"

Each of the seven specimens examined is nearly pure calcium and magnesium carbonates. The admixtures of iron, alumina and silica are quite insignificant.

9. *Minerals of Ontario.*—Professor Willet G. Miller, of Kingston, has recently published in the Ninth Report of the Bureau of Mines, Ontario (pp. 192–212), a list of the minerals found in the Province of Ontario, with notes in regard to their occurrence and characters. This paper is accompanied by a large map of the mining district of Sudbury, with the location of the nickel deposits noted upon it. This gives an interesting representation of the mineral wealth of this region. As is well known, the ore is chiefly pyrrhotite, carrying some nickel. The average of several analyses for each of the five townships in the Sudbury district gives amounts varying from 1·94 to 2·99 p. c. Pentlandite and nickeliferous pyrite also occur in the region.

10. *A Text-book of Important Minerals and Rocks, with tables on the determination of minerals;* by S. E. TILLMAN. Pp. 176, 8vo, New York, 1900 (John Wiley & Sons).—This concise presentation of the principal facts of mineralogy, with brief accounts of the important species, will be found useful by teachers who do not want a more extended work. Some forty pages are devoted to determinative tables, and the closing part of the volume deals with common rocks of different types.

11. *Los Minerales.*—Su Descripción y Analisis con especialidad de los existentes en la República Argentina, por el Dr. GUILLERMO BODENBENDER. Pp. 306. Córdoba; 1899.—Dr. Bodenbender

has given here a brief description of the common mineral species with particular reference to their occurrence in the Argentine Republic. The volume is arranged so as to be suitable for purposes of instruction.

III. Botany.

1. *Monograph of the North American Umbelliferæ;* by J. M. Coulter and J. N. Rose. (Contributions from the U. S. National Herbarium, vii, 1–256, 8vo, Washington, December 31, 1900.)—It is more than twelve years since Messrs. Coulter and Rose published their useful Revision of the North American Umbelliferæ. During this interval much new material has been accumulated toward the further clarification of this difficult group, and the present welcome publication has expanded to some 250 pages. Prefatory lists and tables show clearly the bibliography, statistics and generic synonymy of the family, careful attention having been devoted to the question of generic types. The generic key is artificial, but is based, as must be the case in this group, primarily upon fruit characters and inflorescence, much weight being ascribed to the number and arrangement of the oil-tubes. In the descriptive portion of the work the characterizations are mostly rather brief, greater space than usual having been given to the detailed citation of *exsiccatæ*, a feature which will render the treatment—at least to the professional botanist—much clearer and more valuable than the introduction of fuller descriptions. There are a few habital plates and many clear and excellent text-figures, mostly of the fruit.

Probably the most significant single change from the earlier treatment is the separation (as Lomatium) of the American plants hitherto referred to the genus Peucedanum, which is now regarded by the authors as strictly gerontogeous. It is to be regretted that the authors have felt it desirable to recast their nomenclature according to the Rochester Code, notwithstanding its serious defects, which have been often and clearly pointed out, and which render its general acceptance impossible. The geographic ranges assigned might, in some few instances, have been extended; thus *Leptocaulis echinatus* Nutt. occurs in Southern Missouri (Eggert). A few ranges are vaguely given which might with a little trouble have been made more definite; thus *Erigenia bulbosa* Nutt. is said to grow in the "United States and Canada east of the Great Plains," but it is lacking in New England and the maritime provinces. A more usual case seems to be the repetition of a compiled traditional range not fully borne out by the specimens examined. In this the authors appear to have been too conservative; for, considering the vast amount of material which they have studied—including all the larger public and many private herbaria—who can say better than they where a given American umbellifer occurs? It is, therefore, disappointing to find them still reluctant to relegate to

merited oblivion such venerable spooks as the New England *Thaspium aureum*. Surely it is not only the privilege but the duty of monographers to pass upon the validity of old and unsubstantiated reports.

In the interpretation of species the authors have on the whole been cautious, yet several are launched (e. g., *Hydrocotyle australis* and *H. cuneata*) which appear to rest upon fine technical characters unaccompanied by habital differences of moment. While not prepared to challenge the validity of any of these species, we may say that they suggest the artificial category rather than species distinct in nature. Species with the opposite failing, in which distinctions of foliage and habit are unsubstantiated by satisfactory or constant differences in flower or fruit, are also found, as, for instance in the southern *Cicuta Curtissii*, which would be good enough provided the fruit maintained its orbicular form and never exceeded the assigned 2^{mm} of length, but unfortunately it is variable in these regards and the northern *C. maculata* sometimes has suborbicular fruit which falls short of its ascribed length of 4^{mm}. Similarly, a close scrutiny of the problematic *Sium Carsonii* Durand would have shown the authors that the supposed technical distinctions are, even in the original Pocono material, not invariably so strong as stated. Indeed, in a considerable suite of specimens it is difficult to draw a satisfactory line between this species and *C. cicutæfolium*, and it is known that under certain circumstances (changes of water-level) *S. cicutæfolium* transforms itself into states simulating so closely *S. Carsonii*, that, when so wide a variation is permitted to the former, it seems highly artificial to separate the latter upon trifling differences of degree.

In the successful elucidation of the Alaskan *Cœlopleurum Gmelini* Ledeb. and separation of the nearly allied *C. actæifolium* Coult. and Rose, of our northeastern flora, the authors have rendered a considerable service.

Genera in the Umbelliferæ are apt to appear technical rather than natural and this may be necessary in a group of such uniform floral structure and gradually varying habit, yet it is questionable whether technical subdivision is not carried too far when such habitally identical plants as *Leptocaulis patens* and *L. divaricatus*, with very similar fruit, are placed in separate genera owing to the different number of oil-tubes. The logic of such a course becomes still more doubtful when we see that the not very remote genus Sanicula is permitted to have as many or as few oil-tubes as it likes.

In several places the authors commit the common error of describing thick bodies, like the fruit of Sanicula, with such terms (of two dimensions) as *orbicular*, *elliptical*, or *oval*, instead of *globose*, *ovoid*, etc. B. L. R.

2. *Foundations of Botany;* by JOSEPH Y. BERGEN. 8vo. Pp. xii, 669. Boston, 1901 (Ginn & Co.).—Under the above title Mr. Bergen has just issued what is virtually a revised edition of

his "Elements of Botany." Preserving all the valuable features which have made the "Elements" one of the most popular and useful text-books of the last decade, Mr. Bergen has added considerably to the laboratory exercises upon plant anatomy and physiology, increased the number of illustrations, replaced certain figures by much better ones and incorporated a fuller treatment of the cryptogams by Mr. A. B. Seymour. The work, which is the outcome of many years of practical experience in teaching botany, makes a pleasing impression throughout and at every point bears evidence of care and good judgment. Appended to the text-book is a partial flora, arranged in the sequence of Engler and Prantl's "Natürlichen Pflanzenfamilien," and including some seven hundred flowering plants selected from those most available in spring time in our northeastern and middle states. It is designed, of course, to familiarize the pupil with the common plants of his region and bridge the difficulty which must be encountered by a beginner in the immediate use of more complete and technical manuals. Whether such a simplified flora proves more helpful or misleading must depend largely upon the experience and good sense of the teacher,—qualities which even this well-nigh ideal text-book cannot wholly offset. B. L. R.

3. *Flora of Vermont, a List of Fern and Seed Plants growing without Cultivation;* prepared by E. Brainerd, L. R. Jones, and W. W. Eggleston. (Reprinted from the Twentieth Vermont Agricultural Report; 8vo, 113 pp. Burlington, Vt.)—By its excellent arrangement, clear typography, and copious annotation, the recently issued catalogue of Vermont plants makes a favorable impression. It is evidently the outcome of much active exploration by the members of the Vermont Botanical Club, the results having been carefully verified and arranged by the editors. Each entry in the main catalogue rests upon plants personally examined by the compilers except in a few cases in which other authorities, usually well-known specialists, are cited. No attempt is made to swell the bulk of the flora by repeating second hand reports or unverified records. These, however, are appended in a sort of supplementary *limbo*, where without lessening the trustworthiness of the main catalogue, they will doubtless continue to stimulate renewed search. The arrangement of families is in accordance with the generally approved sequence of Engler and Prantl. The nomenclature is conservative and synonymy sufficient and well-selected. With one or two exceptions the editors have considerately avoided making new combinations, which they rightly regard out of place in local floras of composite authorship. B. L. R.

4. *Catalogue of the African Plants collected by Dr. Friedrich Welwitsch in 1853–61.* Dicotyledons, Part IV, Lentibulariaceæ to Ceratophylleæ; by William Philip Hiern. Pp. 785–1035. London, 1900.—This catalogue of plants collected by Welwitsch in one of the most interesting parts of Africa forms one of the publications printed by order of the trustees of the British Museum, and is an especially important contribution to our

knowledge of the distribution of plants in Africa. Contrary to what one would have supposed, the Bignoniaceæ are represented by very few species. Acanthaceæ and Verbenaceæ are only fairly well represented and the same is true of Labiatæ, although a considerable number of new species of the last-named order are described. Of the Selagineæ, which are abundant at the Cape, none were known in West Tropical Africa previous to Welwitsch's discovery of three species, which are said to be among the most delightful of the plants of Huilla. "The negresses, who are in general but little susceptible to the beauties of nature, are in the habit of weaving in their head-dresses the flowering branches of the two species of Selago." The Proteaceæ, characteristic plants farther south, are represented only by Leucadendron with six species and Faurea with three species. The Loranthaceæ, which increase progressively from the sea coast towards the highlands of the interior and culminate in the mountainous forests of Pungo Andongo and Huilla at an elevation between 4,000 and 6,000 feet, are well represented by 28 species. The Euphorbiaceæ are numerous and those near the sea shore and on high plateaus have the cactus-like habit, while in the mountainous wooded region are found foliaceous climbing and arborescent species which resemble in habit orders like Convolvulaceæ, Urticaceæ and Leguminosæ. W. G. F.

5. *Botany: an Elementary Text for Schools;* by L. H. Bailey. Pp. xiv+355, with 500 figures. New York, 1900 (The Macmillan Company).—Two years ago, Professor Bailey published his "Lessons with Plants," which soon became favorably known to the botanical public. His new text is written in the same spirit but is rather more comprehensive in its scope. The book is divided into four parts: the first of these, occupying rather more than half the volume, deals with "the plant itself"; the second part treats "the plant in its environment"; the third gives a short account of "histology, or the minute structure of plants"; while the fourth, entitled "the kinds of plants," includes descriptions of a number of common wild and cultivated plants, with analytical keys to aid in their determination. The subject-matter, written in the author's usual style, requires little comment. One cannot help being surprised, however, at the admission of such topics as the "burst of spring" on page 40, and the "expressions of plants" on page 60. Possibly this is explained by the introductory statement that the book was written for the pupil rather than for the teacher. Although some of the half-tone figures are inferior in quality, the illustrations are, for the most part, satisfactory and well selected. Certain of them, however, might have been omitted without detracting from the value of the book, figures 347 and 380, for example, bringing out essentially the same points. A. W. E.

6. *Plant Life and Structure;* by Dr. E. Dennert, translated from the German by Clara E. Skeat. Pp. viii+115, with 56 figures. London, 1900 (J. M. Dent).—This little volume is issued

as one of the Temple Primers. It gives a short account of the plant's various organs and of the work which they do. The topics treated are divided under three headings: the internal structure of plants (anatomy), the external organs of plants (morphology), and the life of the plant (physiology). The book is so concisely written that it is not always clear, and the general reader might easily gain from it incorrect ideas about some of the most important botanical facts. A. W. E.

IV. Miscellaneous Scientific Intelligence.

1. *Comparative Physiology of the Brain and Comparative Psychology;* by Jacques Loeb. 8vo, pp. x, 309. New York, 1900 (G. P. Putnam's Sons).—The motive of this very interesting work is well stated by the author in the following words of the preface: "It is the purpose of this book to serve as a short introduction to the comparative physiology of the brain and central nervous system. Physiology has thus far been essentially the physiology of vertebrates. I am convinced, however, that for the establishment of the laws of life-phenomena a broader basis is necessary. Such a basis can be furnished only by a comparative physiology which includes all classes of the animal kingdom." The nervous phenomena in medusæ, ascidians, actinians, echinoderms, worms, arthropods and mollusks are discussed in succession, and then those of vertebrates. Prof. Loeb is strongly anti-metaphysical, supposes all nervous and mental phenomena due to physico-chemical changes in cell protoplasm, and regards the dynamics of the process of association as the true problem of brain physiology. Whether its conclusions are accepted or not, the book will be useful and interesting to the student of biology as well as to the special student of physiology. The metaphysical psychologist also might find mental stimulus in it. S. I. S.

2. *Microbes et Distillerie;* par Lucien Lévy. 8vo, pp. vi, 323. Paris, 1900 (Carré et Naud).—The first and larger part of this manual, intended specially for the use of distillers, gives a concise account of the more important technique of microbiological investigation and a review of the biology of the organisms (here grouped under the general term microbes) which concern the brewer and distiller. The description of the various forms of yeast and their properties is of interest to the general biologist. The second part is devoted to the theory of the application of microbiology in the distillery. The book is fully illustrated with diagramatic outline figures. S. I. S.

3. *Der Gesang der Vögel, seine anatomischen und biologischen Grundlagen;* von Valentin Häcker. 8vo, pp. viii, 102. Jena, 1900 (Gustav Fischer).—In the first part of this memoir Prof. Häcker describes the structure of the vocal organs of birds and points out important sexual differences in the anatomy of the syrinx. In the larger and very interesting second part he dis-

cusses the singing and other sound-producing instincts and their significance in connection with wooing, pairing, etc. S. I. S.

4. *The O. S. U. Naturalist*, published by the Biological Club of the Ohio State University.—This new journal, commenced in November, 1900, and to be published monthly from November to June (50 cts. per year), is to be devoted especially to the Natural History of Ohio. The editor-in-chief is Prof. John H. Schaffner; he is aided by associate editors in five different departments. The numbers already issued contain, among others, several interesting botanical papers.

5. *Ostwald's Klassiker der Exakten Wissenschaften.* Leipzig, 1900 (Wilhelm Engelmann).—The following are recent additions to this series of Scientific Classics, which becomes continually more valuable as it gains more and more completeness.

Nr. 5. Allgemeine Flächentheorie (Disquisitiones Generales circa Superficies Curvas); von Carl Friedrich Gauss (1827). Pp. 64.

Nr. 114. Briefe über Thierische Elektricität: von Alessandro Volta (1792). Pp. 161.

Nr. 115. Versuch über die Hygrometrie. I Heft. I. Versuch Beschreibung eines neuen vergleichbaren Hygrometers. II. Versuch Theorie der Hygrometrie. von Horace Bénédicte des Saussure. Pp. 168.

Nr. 116. Die Darstellung ganz willkürlicher Funktionen durch Sinus- und Cosinusreihen; von Lejeune Dirichlet (1837) und Note über eine Eigenschaft der Reihen, welche discontinuirliche Functionen darstellung; von Philipp Ludwig Seidel (1847). Pp 58.

Nr. 117. Darstellende Geometrie von Gaspard Monge. (1798) Übersetzt und herausgegeben von Robert Haussner. Pp. 217.

Nr. 118. Galvanismus und Entdeckung des Säulenapparates 1796 bis 1800. Von Alesandro Volta. Pp. 99.

6. *The Director-General of the Geological Survey of the United Kingdom.*—The announcement has just reached us (January 15th) that Sir Archibald Geikie has intimated his intention to retire from the post of Director-General of the Geological Survey of the United Kingdom, an office which he has so ably filled for the past twenty years, on March 1st next. In 1855, at the age of 20, Sir A. Geikie became an Assistant on the Geological Survey of Scotland, and he was made Director for Scotland in 1867. In 1881 he was appointed to succeed Sir Andrew Ramsay as Director-General of the Geological Survey of the United Kingdom. He has seen forty-six years' service, but is now only in his 66th year. We rejoice to learn that Sir A. Geikie has no intention of retiring from active participation in geological work, and that neither his hammer nor his pen are to be laid aside for some years to come.—*Geol. Mag.*, February, 1901.

NEW GEOTECTONIC MODELS

FOR THE ILLUSTRATION OF THE

ARCHITECTURE OF THE EARTH'S CRUST.

Constructed by Prof. Dr. L. DUPARC (Geneva), and by Prof. Dr. A. SCHMIDT (Bale).

These models, made of plaster, are constructed in such a manner as to show not only the geological features of the surface, but also on the sides diagrammatic sections illustrate the structure of the underlying crust. To each such model belongs a cap representing the masses of rocks, which are supposed to have been worn away by denudation, and showing the way in which the folding of the strata has taken place. The motives are taken from some of the most interesting parts of the Alps and the Jura Mts. in Switzerland. Among these are also two different representations of the renowned "*Glärner double fold with inversion and thrust-plane.*"

Price of the set of 8 models by Prof. Dr. L. Duparc, size about 40 x 20 x 10 cm., the Glärner double fold about 100 x 22 x 10 cm. $100.00
Price of the Glärner-double-fold model by Prof. Dr. A. Schmidt, size about 100 x 22 x 10 cm. ---------- 25.00
(An accurate description of these models will be sent free on application.)

New Collections of Rocks and Thin Sections.

Collection A. In addition to the well-known collection of 250 rocks and thin sections, according to Prof. Dr. Rosenbusch's book on Petrology, I have now arranged an extension of the same, consisting of 30 rocks and sections; most of them are very rare and interesting types of rocks which I was fortunate enough to collect during the last year.

(Such rocks as Monchiquite, Tinguaite, Leucitsyenite, Gautëite, Borolanite, Ijolithe, Jacupirangite, etc., etc.)

Collection B. This collection has been arranged according to Prof. Dr. H. Rosenbusch's book, "Elemente der Petrographie," and contains only rocks and sections of the crystalline schists and sedimentary rocks, thus forming a

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Price of collection A, 30 specimens, size 8½ : 11 cm.= $13.50
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ESTABLISHED BY BENJAMIN SILLIMAN IN 1818.

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Sphalerite crystals, simple tetrahedra, Crested Butte, Colorado.
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Tellurides from Boulder Co., and from the Cripple Creek district, a large and highly interesting assortment.
Blue corundum in matrix from Montana.
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Herderite, in good crystals, from Mt. Apatite, and in matrix specimens, from Stoneham, Maine.
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Hancockite, leucophoenicite, pink wollastonite, hardystonite; also
Green willemite, fowlerite, jeffersonite and franklinite from Franklin Furnace, New Jersey.

RESTORATION OF

STYLONURUS LACOANUS, CLAYPOLE

By Dr. C. E. Beecher,

Yale University Museum, New Haven, Conn.

This species of Stylonurus ranks not only as the largest of the genus, but also as the most gigantic American arthropod yet discovered. The restoration was described by Dr. Beecher in a previous number of this Journal, where it is also figured. It is based on numerous remains of this and allied species, and so may be relied upon to portray with considerable accuracy this huge Merostome from the Catskill Group of New York and Pennsylvania.

Remains of the Stylonurus are scarce, and material sufficient to illustrate the genus is found in but few museums.

The animal is represented as lying on a slab measuring $5'–5'' \times 2'–11''$, which is filled by the restoration. With its great crawling legs extended to their farthest span this great arthropod would have measured about eight feet (242 c. m.) across, and nearly five feet (147 c. m.) in length.

We have acquired from Dr. Beecher the right to issue this model and offer it, packed and delivered to transportation company, for $25.

For information concerning Dr. Beecher's *models of Brachiopods* showing their embryology and the anatomy of their dorsal valves, and his *models of Trilobite* showing all appendages, also for Professor Marsh's restoration of *Dinoceras mirabile*, as well as for actual fossils and casts of fossils, or any other objects of Natural History, address

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